Integrated support system for access to information in urban space with use of GPS and GIS systems

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Introduction

This monograph is part of the project entitled “The Integrated support system for access to information in urban space” implemented as part of the 10th competition of development projects co-funded by the National Centre for Research and Development.

The basic aim of the project is to create a pilot version of the system which provides the users of urban space with comprehensive and up-to-date spatial information accompanied with descriptive attributes. The system employs innovative solutions involving interdisciplinary approach to information sharing. As part of the project multifaceted research has been conducted into groups of users and their needs. This is directly reflected in the design of the system’s functions.

The project is the combination of a human-centered approach manifested in attention to human needs and an engineering approach to problem solving. Its creators concentrated on specifying a set of features and criteria according to which the users of mobile tools search for information. The goal was to increase the level of information available to users to facilitate decision-making. The versatility of the proposed system required employing professionals in the fields of ergonomics, IT and quality management, as well as practitioners dealing with mobile teleinformation systems.

The sources of inspiration to deal with this subject were scientific interests of the team members and their works, which were part of their own program entitled “The acceleration of knowledge in the fields of technology, mathematics and natural science in Poland”. The importance and timeliness of the subject is related to – among other things – the development of teleinformation technologies, the links between engineering and technology and social sciences, and their application have become a very significant factor for the development of the economy, contributing greatly to the improvement of the quality of living in a society. Improving the quality of living is to a large extent possible thanks to the application of IT and teleinformation technologies in everyday life. Therefore, streamlining the processes of communication and decision making (in both professional and non-professional life) through providing information whose form and content correspond with the expectations of recipients clearly improves the conditions of living.

In order to optimize the results of the project, our team has efficiently cooperated with both institutions of public administration and economic entities. A possibility to integrate databases and fields where the proposed solutions can be applied in an urban space have been discussed with the employees of the Poznań city hall. The LG Electronics Polska Sp. z o.o. company supported the
project activities by providing (free of payment) the latest models of mobile phones for the purpose and period of testing. In order to recognize the needs of users and in order to analyze the functionality of applications, the project executors cooperated with two research companies – TNS Pentor Poznań and Cogision Sp. z o.o. As far as testing of information integration is concerned the project executors cooperated with another partner – the City-nav Sp. z o.o. company.

This monograph has been written in order to present the most important issues dealt with within the project of “The integrated system supporting access to information in public urban space”.

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1. Comparative analysis of the category of quality information

WŁADYSŁAW MANTURA

1.1. Introduction

There is much evidence suggesting that quality and information belong to the fundamental categories used in the lives of people, organizations and societies. In the most general approach – people use these two categories to learn about the reality and to shape it. Quality and information are used, among other purposes, to identify the needs of entities (people, social groups and organizations) and ways to satisfy these needs. All entities have information and quality needs, the satisfaction of which is a precondition for satisfying many other kinds of needs. The extent to which these information and quality needs are satisfied has a significant impact on the quality of life. These categories are used commonly in scientific, professional and amateur practical activities. The awareness of the meaning and role of these categories is also an undeniable social phenomenon.

In science, the methodology of the qualitative overview belongs to the oldest, most basic, universal, common and constantly valid ways of learning about the reality and how it is transformed by human. The result of applying this methodology is the presence of the quality issue in all spheres of human activity: scientific (theoretical) and practical, creative, designing, productive and operating, individual and social, economic, cultural, political, ecological and many more. The applications and meaning of quality categories are particularly well established in economic activities, especially in the productive sphere, and in many scientific disciplines, in particular: philosophy, economics and sciences of organization and management. In a mostly intuitive way the two categories are also used in common everyday practice of individuals and societies.

Practical interest in the issue of quality has always been caused mostly by the needs of economic entities operating in the following spheres: production, trade and product operation. The economy makes the foundations for material and spiritual existence of each society through designing, producing and providing entities with products of a suitable quality. A quick development of empirical research into quality over the last decades can be interpreted as a manifestation of a growing significance of the pro-quality orientation (in contrast to the quantity orientation) and of the fact that the level of efficiency
and effectiveness of the economy is increasing. Increasingly better economic activity and its results ensure long-term civilization development and growth of the estimated quality of life of individuals and societies. At the same time, the reserves of the resources freed by the use of pro-quality strategies in the economy enable further intensive and extensive development. Another increasingly important factor in the shaping of the quality of life is the pro-quality orientation in the activity of non-business organizations.

A category even more common in the life of human than the category of quality is the category of information. It is an original, natural and fundamental quality (feature, attribute) constituting the human species. It glues the social life. Human has always created and used the designates of the concept contemporary known as information. It is relatively obvious that information is an essential precondition for every conscious activity of every entity. An even further-reaching thesis can be formulated – that information determines the essence of human consciousness and existence. Accepting this thesis means accepting that information categories in every conscious activity of entities serve the purpose of inventing, starting and modeling (representing) this activity and its components. An example of such approach to the relation between an entity and information can be found in the information and decision-making processes widely discussed in management sciences. The omnipresence of the category of information and its designates makes it conceptually quite obvious, so many authors do not even define the term.

The dynamic development of information technologies which has taken place over the last decades has significantly extended the scope of possibilities in which information may be used in the activity of entities. We are talking here especially about the progress concerning information technologies (including computer technologies) and telecommunication technologies, which systematically increase their capabilities in the scope of acquiring, collecting, processing, storing and sending information. At the same time, the awareness of entities concerning the role and significance of information as a valuable resource in their activities is also growing. The proper creation and employment of this resource increases the efficiency and effectiveness of these activities. This is true for the activities of both people and organizations. The growing awareness of the significance of information results in popularizing and developing in literature the ideas of information society and knowledge-based society [Materska, 2007; Papiszka-Kacperek, 2008]. “An information society is the society and economy in which information and knowledge become the fundamental factor of production (and consumption)” [Papiszka-Kacperek, 2008, p. 367].

The above-indicated conditions are sufficient reasons to conduct a comparative analysis of the categories of quality and information, which is done further in this chapter. An additional justification for the need to conduct this analysis is the hypothesis that there is a strict relationship between these categories. The analysis takes into account the similarities and differences between these two
1. Comparative analysis of the category of quality and information as well as the scopes of these concepts. First of all, quality and information are properly characterized as categories of qualitology and information theory.

1.2. Quality as the fundamental category in qualitology

From the analysis of literature and from observation of the practical approach, quality categories are more and more often a subject of scientific research; nevertheless, it is difficult to state that qualitology as the science of quality has precise methodological foundations and a certain position among other scientific disciplines. There is not even a clear and widely accepted definition (made on the basis of a synthesis of the existing relevant knowledge) of the central category, i.e. the category of quality. In practice, the terminological and managerial standard of the quality issue included in the ISO 9000 standards becomes more and more important. These standards are used for the purpose of quality management in organizations. Therefore, at present, qualitology should be treated as certain various ideas of the holistic organization of the existing knowledge about quality [Kolman, 2009; Mantura, 2010]. This knowledge is relatively more developed in the field of quality engineering than – as far as the quality theory is concerned.

The category of quality was for the first time mentioned in the works of Plato, the father of objective idealism, and referred to with the Greek term of poiotes. The concept of quality referred to concrete things meant an extent to which these things reached the state of perfectness (compliance with the perfect ideas of things). It is then estimating (axiological) description of quality. Here, it is worth mentioning that as far as common practice and social awareness is concerned, quality is usually a particular kind of value determined by the extent to which a given thing (e.g. product, service, work or art) meets certain requirements. This means that, in common applications, the category of quality understood in this way (as in Plato’s works) makes it possible to – among other things – satisfy the universal need to order things according to their values (the preferential ordering of things). The category of value expresses an important type of relation between human and things, and other humans. The creative activity and manufacturing entities shape reality according to the accepted system of values and postulated patterns, and control the effectiveness of this activity. In a Platonic sense, the result of this control is called quality. Aristotle, the author of the theory of matter and form, included quality in a set of ten most general categories of description and knowledge of the substance, i.e. what is being evaluated. Unlike Plato, Aristotle understood quality as a set of particular attributes distinguishing a given

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1 Quality is there defined as an extent to which a set of inherent properties meets requirements.
thing from other things of the same kind. The notion of quality – the word *qualitas* – was introduced into Latin by Cicero. The term meant a feature, characteristic, an attribute of a given thing [Mantura, 2010, p. 24-25].

The quoted philosophical terms referring to quality indicate that **the category of quality performs a general, important and universal cognitive (epistemological) function in relation to everything**. This function is included in the answer to the following general questions: What is, was, or will be the thing like? or: In what way does this thing, did this thing or will this thing exist? The cognitive function of quality includes also, as its special case, an axiological function, reflected in the answer to the following question: What is, was or will be the value of this thing? Such question refers us to **the category of value** as a particular attribute of a thing’s quality concerning the value relation between human and thing. The second, special and also very important, feature taken into account when determining the quality of things is the **category of quantity**.

Considering the relationship between the ontological categories of matter and thing and epistemological categories of quality and attribute, it is assumed that attributes and qualities belong to the matter and thing and do not have an independent existence. Qualities and attributes exist in a relationship between the cognitive entity and the sources of its experiences, observations and thoughts. They are abstracts making it possible to create **information models (images) of the components of reality** by the cognitive subject. All epistemological categories functioning in the consciousness of the cognitive subject are related to this special position of his and they are the material for the thought processes and their **creative results** as well as the processes of communication between entities with the use of specific languages.

In the developed idea of the bases of qualitology, it was considered reasonable to assume that the underlying epistemological categories are the categories of **quality and attribute** [Mantura, 2010]. Gradual decomposition, instantiation and exemplification of these categories occurs in the processes of exploring the detailed information and knowledge about objects, which is one of the tasks of particular academic disciplines and fields of practice. This process results in designates of the general terms of quality and attribute, related to particular objects. The adopted scientific approach of qualitology reflects the **quality overview of the reality** and is assumed to include all the possible characteristics of every object; it also takes into account the natural desire of entities to acquire the fullest possible and the most comprehensive knowledge of the nature of objects.

The development of the scientific approach of qualitology is reflected in three general research perspectives [Mantura, 2010, p. 36]:

- the **descriptive** perspective, in which the methods of qualitative modeling are used to learn about the nature of objects through answering the question: what are, were or will they be like?
the *comparative* perspective, in which comparative research methods are used to classify and order objects through answering the following question: in what way are they, were they or will they be similar to or different from one another?

the *axiological* perspective, in which the methods of quality evaluation are used to achieve the value hierarchy of quality categories and objects through answering the question: what are they, were they or will they be worth?

In formulating the aforementioned research perspectives a universal methodological principle was taken into account according to which each of the perspectives takes into account the fourth – perspective – *time*, which makes it possible to refer the quality of objects to the past, present and future.

When formulating the general, supreme aim of qualitology, it has been assumed that it is creating a scientific basis for the quality recognition and quality shaping of the reality by human [Mantura, 2010, p. 38].

In qualitology literature there is a significant number of varied terminological proposals concerning the basic terms. Most of the definitions are related to the axiological recognition of quality by Plato or the descriptive recognition of quality by Aristotle. Accordingly, the definitions of quality may be divided into three groups [Mantura, 2010, p. 45]:

- definitions which describe quality as a set (system) of attributes (characteristics, properties, features, qualities, traits) characterizing a given object and distinguishing it from other objects,
- definitions which describe quality as a degree (level) in which a given object meets the requirements arising from certain needs of certain entities,
- definitions which describe quality as a set of attributes of a given object which meet a set of requirements arising from certain needs of certain entities.

The term of *attribute* is assumed to be the basic, elementary category of qualitology and it is treated as the primary (undefined) term. This does not exclude the possibility that the reader may be mentally directed at the understanding of this term in a way consistent with the author’s. To explain the term we could add that it is a separated element of what is stated about an object as a result of a thought process and the formulation of the answer to the following question: *what is this object like?* Therefore, an attribute is a general name of a certain *portion of information* about objects. In the processes of developing, making more concrete and detailed, and making *designates* of this generic name, corresponding changes in the field of information and knowledge about objects occur. It is also worth noting certain similarities in how the term of attribute is understood in qualitology and how the term “variable” functions in mathematics.

From the aforementioned reflections it is clear that an attribute is the most *universal, fundamental and elementary abstract* whose designates carry certain pieces of information, which are materials used for the creation of other,
more complex from the informative perspective and more concrete abstracts. This complex and most general abstract will be, first of all, the term **quality** [Mantura, 2010, p. 47]:

**Definition 1.** Quality is a set of attributes. 

\[ J = \{c_1, c_2, c_3, \ldots\} \] or \[ J = \{c_1, c_2, \ldots, c_n\} \] or \[ J = \emptyset \].

The adoption of attribute as the primary term results in that *definiens* is composed of primary terms. A concept of set as well as the concept of belonging to a set are fundamental, primary concepts in mathematics used in the meaning of multitude (of a group, class, amount, space) of objects called elements belonging to a given set. The elements of set \( J \) called quality are attributes \( (c_1, c_2, \ldots, c_n) \). The triple formula of quality in description 1 means that it may be an infinite, finite or empty set.

One of the most fundamental characteristics of quality is the **cardinality** (power) of a set expressed in a natural number. If the attributes are ordered according to the adopted ordering relation, another attribute of a set will occur – **order**, and quality will take the form of an ordered set. The above reflections bring us to an important conclusion that also to a given quality may also belong.

The designates of quality as concrete abstracts are made in strict relation with objects \( (p) \) to which belong: \( J_p \leftrightarrow p \). Hence, the fundamental principle in the creation of quality as a set of attributes is the adoption of the property that “attributes belong to objects – \( F(c) \)” as the basis for accepting certain attributes as parts of the quality of given objects. In an unitary approach, those and only those attributes to which property \( F(c) \) belongs, are included in the quality of an object: \( \{c \in J_p : F(c)\} \).

The property of attributes belonging to objects is determined through research activities (discovered quality) or creative project activities (postulated quality). The discovered quality concerns existing objects and the postulated quality – designed (artificial) objects. The definition of an object is as follows [Mantura, 2010, p. 49]:

**Definition 2.** The quality of an object is a set of attributes belonging to it, 

\[ J^p = \{c^p_1, c^p_2, \ldots, c^p_n\} \].

In accordance with Definition 2, recognizing the quality of an object involves discovering and postulating, as well as formulating a set of attributes of this object as a result of cognitive (diagnostic and prognostic) processes or designing processes in which this object is the subject of diagnosing, forecasting or designing.

In order to illustrate the operation of ascribing attributes and quality to objects, two **quality functions** can be formulated. Function \( F_c \) represents the analytical approach and ascribes attributes from set \( C \) to objects in set \( P \).

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2 An object is any element of the material or immaterial (abstract) reality.
1. Comparative analysis of the category of quality information

Function $F_j$ represents the synthetic approach and ascribes qualities from set $R_j$ to objects in set $P$ [Mantura, 2010, p. 50].

$$\text{where: } F_c : P \rightarrow C \text{ and } F_j : P \rightarrow R_j (1)$$

- $F_c$ – the quality function for attributes,
- $F_j$ – the quality function for quality,
- $C$ – the set of attributes,
- $R_j$ – quality set ($R_j = \{J_1, J_2, ..., J_n\}$, the set of the sets of attributes – the family of sets$^3$),
- $P$ – the set of objects.

One of the cognitive operations referred to the quality of objects is valuation, based on the application of the axiological criterion of value (an attribute of the name “value”) and the value ordering relation $R_w$. This operation illustrates the transition from a neutral characteristic of an object (the non-valuation quality) to its axiological characteristic, including teleological, ethical, aesthetic, economic, psychological, useful and other (the quality of valuation). The definition of the valuation quality of an object is as follows:

**Definition 3.** The value quality of an object is the value characteristic and value ordered set of attributes of this object $(J, R_w)$.

One of significant problems in determining the quality of objects is the proper formulation of designates of the term “attribute”. The correctness of the formulation of designates of this term is related first of all to the level of development of the language as an instrument to manipulate information within particular academic disciplines and areas of practice. The designates should be:

- relevant, clear, communicative, logical and concise. This means that designates should be: relevant to the subject considered, to studied phenomena and facts; clear and semantically (notionally) precise; communicative for a specified group of people; logical as regards the aspect of logical value, formula and relations to other designates as well as concise in writing.

The concrete systems of designates of the term “attribute” applied in particular academic disciplines reflect their research contexts referred to particular fragments of the reality. It is justified to claim that there are designates of this term common for many academic disciplines and many areas of practice. This stems from the fact that they are understood and applied by a relatively large group of people of various specialties. However, a situation like this is conducive to an increased risk of blurring and heterogeneity of the notional designates of attribute and makes it more difficult to adopt a single semantic convention.

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$^3$ A family of sets is a set whose all elements are sets.
The quality of objects determined on the basis of attributes expresses the first and general level of the knowledge of them. Such level of knowledge stems from the fact that the names of attributes are formulated in a descriptive way in a given language and determine their notional meaning. The analysis of formulating and applying of attributes brings us to a conclusion that in reality they are identified in objects only in the form of certain states of their own. The result of the development of the concept of attribute is the set of its states. Hence, the set of states of a attribute reflects its internal diversity, details and analytical complexity. If an attribute is to be treated as a variable in mathematics, its state will be each of the values of this variable.

All theoretically possible, stated in the course of research or applied states create the set of states of an attribute: \( S = \{s_1, s_2, s_3, \ldots\} \) or \( S = \{ s_1, s_2, \ldots, s_n \} \), or \( S = \emptyset \), which for measurable (quantitative) attributes is called the range of variations or the gap. For attributes which are values, specific measurement scales, units and systems are used.

The states of attributes express the second and detailed level of the knowledge of nature and diversity of objects to which they belong. Therefore, the following definitions of the state of quality and the state of quality of an object are adopted [Mantura, 2010, p. 51]:

**Definition 4.** The state of quality is the set of states of attributes.

\[ J_s = \{s_{c1}, s_{c2}, s_{c3}, \ldots\} \] or \( J_s = \{ s_{c1}, s_{c2}, \ldots, s_{cn} \} \) or \( J_s = \emptyset \).

**Definition 5.** The state of the quality of an object is the set of the states of attributes belonging to it.

\[ J_{ps} = \{sp_{c1}, sp_{c2}, \ldots, sp_{cn}\} \].

In the operation of assigning states of attributes to an object (just as in the situation of assigning attributes to an object), a logical formula of the following type is applied: \( A \lor \sim A \) (fact A occurs or does not occur) and the following problem is resolved - do particular states of an attribute belong \( (s_c \in J_{ps}) \) or do not belong \( (s_c \not\in J_{ps}) \) to this object?

### 1.3. Quality as the fundamental category in the theory of information

An initial overview of literature enables us to conclude that the theory of information is in the early stages of its development. This is indicated by a diversity and incoherence of the presented ideas, including different approaches to terminology. Some authors treat information as an original term (undefined) whereas other authors formulate definitions, which vary significantly [Flasiński, 2011; Wyczka, 2010; Kisielnicki, 2008; Kowalczyk, 1981; Materska, 2007; Mazur, 1970; Olejniczak, 1989; Papiszska-Kacperek, 2008; Stefanowicz, 2010]. This may be illustrated by the words of Flechter: “the
concept of information is not only the central concept in the theory of information but also one of the most fundamental concepts in cybernetics. At the same time, it is one of the most difficult concepts for anyone who wants to explore cybernetics. Even a cursory review of the literature indicates that the concept is not only defined differently, but also that in the strict definition of the theory of information this notion seems to have a meaning completely different from the one we are used to associate with this word” [Mazur, 1970, p 26]. Relevant opinions of several authors can be found briefly described further.

Marian Mazur distinguishes quantitative and qualitative theory of information, and he himself creates a qualitative theory of information. In the quantitative theory of information, the precise mathematical category of the quantity of information is expressed in Shannon’s famous formula (see [Mazur, 1970, p. 15]). The unit of information, called “bit”, is the amount of information stemming directly from the fact that one of two equally probable events occurred. Hence, recognizing the fact that there was one event from the n number of equally probable events, the amount of information expressed in bits is expressed by the famous Hartley’s formula (see [Mazur, 1970, p. 16]). Such understanding of the amount of information does not include all the situations where there is a need to quantify information, nor does it take into account the intuitive but common understanding of the term.

M. Mazur, signalizing the appearance of publications creating the qualitative theory of information states that they concern issues of the evaluation of the usability of information as far as decision-making problems are concerned [Mazur, 1970, p. 11].

Creating the qualitative theory of information, M. Mazur aims at explaining the essence of the term “information”, its kinds and what information processes involve. Using the achievements of cybernetics, he emphasizes the significance of the transformation of communications as elements of the controlling process. Under the term “communication” Mazur understands “a physical state which differs in a specific way from another physical state in the control circuit” [Mazur, 19708, p. 34]. A developed, original, coherent system of terminology can be understood in the context of the author's complete arguments, however, several defined terms are worth mentioning: informing, pseudo-informing, misinforming, para-informing and meta-informing. The common explanations of these terms mean that informing is receiving communication, pseudo-informing is apparent informing (wordy, vague, unclear), misinforming is false informing (imaginary, concealed, distorted), para-informing is alleged informing and meta-informing is informing on information [Mazur, 1970, p. 209]. Finally, it is worth paying attention to the fact that the qualitative theory of information does not refer to the contemporary concepts of qualitology.

Edward Kowalczyk includes the theory of information in systemic theories and indicates that it refers to cybernetics, statistics and thermodynamics [Kowalczyk, 1980]. The theory of information’s relations to cybernetics are
based on the role of information in control systems, to statistics – on the diversity and probability of events, and to thermodynamics – on the relation between information and entropy. Entropy in the theory of information may be used to measure the amount of information where there is only uncertainty, chaos, doubt and disorder. An important goal of creating and using information is to decrease or even remove these negative phenomena.

E. Kowalczyk uses, among other terms, the term “the information capacity of an object”, which is measured with the amount of information and is proportionally dependant on the extent of complexity of the object’s structure. He distinguishes an information situation in the system of object-observer depending on the properties of the object, attributes of the observer and conditions of observation [Kowalczyk, 1980, p. 31]. He rightly points out to the fact that the notion of information has a psycho-physiological sense and notices that “the theory of information in its existing shape does not enter the field of psychology [Kowalczyk, 1980, p. 32]. Further, he states that “the interpretation of the reality associated with a given individual may be regarded as the essence of the psychological sense of information” [Kowalczyk, 1980, p. 50]. One of the interpretations of information offered by the author is the following: “Information is becoming aware (or even the consequences of becoming aware) of the nature, the meaning of the quantity and extent of the order by an observer” [Kowalczyk, 1980, p. 33].

Bogdan Stefanowicz reviews various definitions and interpretations of the concept of information [Stefanowicz, 2010, p. 13-15]. He concludes that the concept of information exists in cybernetics, the theory of systems, computer science, psychology, quantum mechanics, molecular biology and neuroscience. He distinguishes three approaches to the interpretation of the term “information” which can be found in literature. The first approach treats information as an original concept (undefined). In the second approach, the term is defined according to rules adjusted to the requirements of particular fields of study, taking advantage of such notions as probability, entropy and message. In the third approach, information is described through its attributes and functions. Also, he cites the most general philosophical definition of information: “information is the reflection (reproduction) of the diversity which characterizes the surrounding reality (object, event, process, phenomenon)” [Stefanowicz, 2010, p. 13].

Also the infological concept of information, as described by B. Stefanowicz, is interesting [Stefanowicz, 2010, p. 15-28]. According to them, information is the reproduction (description) of a specific fragment of the reality in the mind of an observer. Their assumption was also that information is the content of a message. The description of a fragment of the reality (reconstruction), its analysis, interpretation and evaluation depend, among other factors, on the available

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4 The infological concept of information was developed by Swedish researchers Bo Sundgren and Bo Langefors [Materska 2007, p. 24].
resources of knowledge and experience of a given observer (called the conceptual thesaurus of the observer) as well as on his psycho-physical attributes and intelligence. The analysis of a fragment of the reality leads to separating in it objects, their attributes and relations between them, taking into account time $t$. The description of object $O$ is formally written as system $K$ [Stefanowicz, 2010, p. 16]:

\[ K : = \langle O, P, t \rangle \] (2)

In the formula (2), $P$ is a predicate describing object $O$ because of its distinguished attributes or relations with other objects belonging to a given fragment of the reality. In the infological concept of information an important role is played by language as an instrument of communication. Language is used to reconstruct content conveyed in the process of communication. However, it is claimed that a language is also responsible for the reduction of content due to its limited terminology and the conceptual thesaurus of the researcher (“This linguistic relativism is responsible for the fact that we see the world as such as the language we use”) [Stefanowicz, 2010, p. 19]. The above reflection bring us to a conclusion that information in an infological sense is subjective (i.e. depends on the observer). Information which does not depend on the observer is objective, i.e. it is information in a datalogical sense [Stefanowicz, 2010, p. 20-24]. Distinguishing information in a datalogical sense makes it possible to use the term information in a situation when there is no need for a message to be interpreted by human. This allows us, among other things, to use such terms as biological or genetic information. As a result, we are dealing with the dual nature of information – subjective (when information is consciously received by concrete recipients) and objective (when it is, in a general sense, potential information for all recipients).

In an infological concept of information, it is claimed that information which the recipient of a message consciously receives depends on the following factors [Stefanowicz, 2010, p. 22-23]:

- the time in which the recipient acquires and analyses the content of a message,
- the conceptual thesaurus of the recipient,
- the problem-task context of the recipient,
- the recipient’s emotional state,
- the overall circumstances in which the message is received.

There is an opinion that the term “information” means a continuous (unlimited) concept. Therefore, as a noun it is used only in singular (as in English and Russian) [Stefanowicz, 2010, p. 27]. In the grammar of the Polish language there are both a singular and plural form of the noun “information”.

An interesting issue described by B. Stefanowicz is the quality of information [Stefanowicz, 2010, p. 93-114]. He identifies and analyses such attributes of information which have an impact on the extent to which it may be
used in practice and which increase its value. Such attributes are treated as the desired ones. The desired attributes include [Stefanowicz, 2010, p. 95-114]:

- the up-to-datedness of information understood as its sufficient compliance with the real state of an object (in a given time – author’s note),
- the reliability of information, resulting from the reliability and accuracy of the methods of its collection and processing,
- the accuracy of information meaning the extent to which the acquired values of attribute correspond with their real values,
- the completeness of information, i.e. the collection of all information concerning a given object, need or aim (the completeness of information is related to the notion of the redundancy of information),
- the clarity of information depending on the application of clear language and precisely defined terms,
- the communicative quality of information, thanks to which the recipient can understand it and corresponding to the recipient’s conceptual thesaurus,
- the flexibility of information as the possibility to use information by various recipients for various purposes and in various systems,
- the relevancy of information, interpreted as the extent to which the information approximates the problem dealt with by the recipient,
- the consistency of information, as a substantive, methodological, linguistic, technical, and organizational compliance of communication components, data collection methods, elements of language, communication techniques, formats and data structures, and components of the information process respectively.

Apart from the desired attributes of information, the author mentions also the undesired attributes such as: fragmentation, vagueness, redundancy, complexity, and ambiguity [Stefanowicz, 2010, p. 103-109]. It may be noted that the undesired attributes may be interpreted in relation to respective desired ones as the positive and negative states of properly formulated aggregated attributes.

Katarzyna Materska deals, among other subjects, with relations occurring between information and knowledge in the context of the society of knowledge and proposes a holistic approach to the nature of the phenomenon of information, integrating views occurring in many academic disciplines [Materska, 2007]. She claims that the theory of information is a misleading name as its fundamental concept is the amount of information and not information itself. She points out that in the reflections on information various research approaches are applied: quantitative, psychological, qualitative, philosophical, systemic, sociological, communicative, process, infological, functional and historical. This variety is probably one of the reasons for four hundred definitions of the term “information” [Materska, 2007, p. 24-25]. Referring the theory of information to economic and management sciences results in interpreting information as a product, which has its producer and user,
and may be the subject of the following operations: storage, shipment, processing and market exchange.

Analyzing different definitions of information, K. Materska cites famous words of T. Saracevic – the most known American researcher dealing with the theory of information – who, asked what information is, replied: “In a scientific sense, the answer to the question is »We don’t know«” [Materska, 2007, p. 26]. From the overview of definitions made by the author it arises that the creators of the theory of information have taken all possible positions with respect to this issue (see: [Materska, 2007, p. 26-31]). The proposed definitions of information emphasize first of all such aspects as content taken from the environment, message included in communication, the removal of uncertainty, data used in action, content ascribed to data. The presented overview of positions includes also the most controversial one which assumes that information is a material being (a thing). As a result, the author, referring to several other authors, claims that “… so far there has not been a good enough definition of information, nor a good theory of information and knowledge” [Materska, 2007, p. 30]. The opinion of Wojciech Olejniczak is similar. He also made an overview of the definitions of information and concluded: “Even this limited choice of terms referring to the notion of information shows how polymorphic this word is with respect to its meaning. The phenomenon of polymorphism is here related mainly to the fact that neither one of the cited definitions corresponds to the intuitive idea of the meaning of the word. Each attempt at defining this notion introduces some new contents to its meaning. These definitions do not reveal but narrow, and as a result obscure its meaning, increasing at the same time its semantic polymorphism” [Olejniczak, 1989, p. 33].

In her reflections, K. Materska accepts both the infological and datalogical idea of information. This is manifested, for example, in the specification of information properties (stable attributes) [Materska, 2007, p. 36-41]:  
- information is objective (datalogical approach),
- information is immaterial,
- information has different meanings for different recipients (infological approach),
- a unitary piece of information describes an object in relation to only one of its attributes,
- information is thematically diverse,
- information reveals a characteristic of synergy,
- information is mobile (may be copied and transported in time and space),
- information is a resource that cannot be depleted,
- information may be processed,
- information is a permanent good (it cannot be consumed),
- information costs,
- information is unevenly distributed in space.
Apart from property, also **the functions of information** are specified – such as: cognitive, knowledge-building, consumer, notifying, decision-making, teaching, control, innovative, meta-informational, cultural, educational, international, communicative, motivational and commanding [Materska, 2007, pp. 41-42].

In her work K. Materska presents the views of various authors concerning the notion of **power** and its cross-classification [Materska, 2007, pp. 42-45] and the relationships between such concepts as mark, data, information, knowledge and wisdom [Materska, 2007, pp. 49-56]. She also cites one of the most popular definitions which “treats knowledge as all the information on the reality together with the skills to use it” and claims that “none consensus has ever been reached in the academic environment with regard to any definition of knowledge” [Materska, 2007, p. 42].

There is a research area related to the theory of information, which is extremely interesting, current and important – the research on **artificial intelligence**. Artificial intelligence is related to the application of modern technology (techniques) in using information. Technologies support or replace human in performing certain mental operations (functions) and usually ensure that these operations are performed more efficiently (more effectively, faster, cheaper, more precise, more resentful, etc.) Mariusz Flasiński presents the problems of artificial intelligence taking into account the epistemological and psychological approaches [Flasiński, 2011]. He mentions and describes thematic areas of mental work in which artificial intelligence is applicable: decision-making, reasoning, problem solving, creativity, pattern recognition, knowledge representation, planning, natural language processing, learning, social intelligence, emotional intelligence, manipulation and locomotion [Flasiński, 2011, p. 227].

To complete the literature overview of selected issues of the theory of information, one developing area of knowledge is worth mentioning – **information management** (knowledge management) [Wrycza, 2010; Kisielnicki, 2008; Olejniczak, 1989; Papisęska-Kacper, 2008]. In this approach, information has become a subject of management and a basis for decision-making and at the same time a tool to satisfy the needs and to achieve the goals of entities. In this approach, information is classified according to selected criteria (attributes) of information such as source of origin, measurement, degree of formalization, time, frequency, level of aggregation, functions, level of management [Wrycza, 2010, p. 63].

In the author’s presentation of the selected issues of the theory of information, the assumed fundamental approach to information is infological (subjective, psycho-physiological). The previously characterized datalogical approach to information will not be applicable due to the adopted assumption and definition of information formulated on its basis. In this assumption only **the sources of stimuli and stimuli themselves are considered objective** (including
signals in the channel of communication Fig. 1.1), which – affecting human sensory organs – initiate thought processes. At the same time, thought processes of each person and the results of these processes are subjective. This, however, does not mean that thought processes and their products initiated by the same stimuli may not be similar in different people. On the contrary, for example, in using linguistic stimuli (symbols) in communication the assumption is that the similarity of ideas, thoughts and its products, initiated with these stimuli, will be as similar as possible in all people using a given language. A tool to achieve this important goal is semiotics, including terminology.

Taking into account these assumptions, the following definition of the term "information" is proposed:

**Definition 6.** What we call information is the products of human thought operating in minds which reflect the reality and create the immaterial reality.

Particular products of human thought are fragments (components, parts, elements) of information.

A fuller explanation of the sense of the term "information" should start from defining consciousness. Due to the many meanings which this term may have, it is assumed that consciousness is an applied skill of human to identify and verbalize thoughts. In this approach, consciousness is a state of mind occurring in time, in which a person knows that he or she exists and thinks (this refers us to a known philosophical sentence “I think therefore I am”). E. Kowalczyk formulated an interesting description of it: “Consciousness is a mirror in which the reflection of the world around us is probably a caricature of the objectively existing reality” [Kowalczyk, 1981, p. 9].

The thoughts of a person depend on external and internal stimuli. The source of external stimuli is the environment and the source of internal stimuli is the “psychophysical space” of a given person. Stimuli are physical in character, which means that they may affect and be received by receptors of the human nervous system. Receptors are sensual tools equipped with sensory nerves capable of receiving certain types of stimuli, such as electromagnetic, audio, chemical, power, thermal, kinesthetic, aesthetical and other stimuli. Commonly known sensory tools of human are sensory organs of sight, hearing, taste, smell, temperature, touch, balance and pain. Impulses arising from the impact of stimuli flow in the nervous system to the brain in which they participate in thought operations. To illustrate this process we can say that stimuli reach us from everywhere and information is born in us. According to the type of source, all stimuli may be divided into two classes. One class are stimuli coming from elements of the material reality. Another class are stimuli coming from elements of the immaterial reality. Some stimuli of this class are signals conveyed in communication processes (Fig. 1.1).
Fig. 1.1. Communication process scheme. Own work
Thinking means conscious operations of processing certain abstract products (including concepts and judgments) and creating some new. It is considered obvious that a necessary precondition for thought operations is memory fulfilling three basic functions: memorizing, storing, and recalling the products of mental operations.

Thought processes start at the moment of perception which means conscious reactions of particular sensory organs to certain stimuli. Thought products of the conscious reaction of particular sensory organs are called sensations. Sensations are elementary, homogenous (with respect to the kind of stimuli) cognitive acts referred to objects which are sources of the stimuli. Sensations may be formulated as attributes of objects.

The comprehensive perception is expressed in conscious simultaneous reactions of all the senses to all stimuli emitted from a given object. Thoughts produced of conscious and simultaneous reaction of all sensory organs are called observations and the thought process itself – perception. Observations may be formulated as sets of attributes of objects. The more complex the object and the more states it can adopt, the more stimuli it generates and the more information about it can be produced.

Another kind of thought products is visions. Contrary to sensations and observations, visions are produced at other times than the situations when stimuli influence sensory organs. There are two basic ways in which visions occur. One of them involves reproduction (recollection) of previously remembered sensations, observations and visions. These are reproductive images. The other way involves the creation – through thought operations – of new visions which are called productive (creative) visions.

Sensations, observations and visions are used for the creation of more complex products of human thought. There is a countless amount of such products which are called works, projects, plans, models, structures, systems, programs, novels etc.

Creativity is an amazing feature of the human mind. Remembered sensations, observations and visions and other products are subjects of transformational thought operations as a result of which new creative products arise. Creative products create a new reality. Creative produces themselves create a new immaterial reality and some of them perform the function of informational patterns for the creation of the new material reality.

The notion of reality involves everything that exists, regardless of the form, conditions, time and way of existence. Human takes a special place in the reality due to his phenomenal quality defined with such attributes as perception, thinking, remembering, imagining, anticipating and creating. The reality is composed of not only material elements – objective, independent and real – but also immaterial elements (abstract, virtual and spiritual) – subjective, dependent and unreal. The elements of the reality may be divided into natural – arisen as a result of natural processes – and artificial – arisen as a result of the cognitive,
creative and productive activity of human. Therefore, the whole immaterial reality belongs to the artificial reality. The fact and form of the existence of a given component of the reality in a given period of time is stated by human as a result of a cognitive process [Mantura, 2010, pp. 31-35].

From Definition 6 it arises that the term “information” is an immaterial element of the artificial reality characterized with the highest level of generality and universality. The term appeared and exists in relation to human existence.

The above reflections clearly show that the products of human thought represent (reflect, model) the existing reality and at the same time create a new reality. A unitary object of representation is an object as any component of the reality. Hence, the special significance and unique role of information in human activity – aimed at cognition, creation and transformation of objects.

One of the most important interpersonal and social relations (much evidence indicates that this is the most important relation) is communication and related to it term “message”. The proposed definitions of these terms are as follows:

Definition 7. Communication is the exchange of information between entities.

Definition 8. A message is a coherent piece of information transferred between entities.

Analyzing Definitions 6 und 8 it is easy to notice that the term “information” as a noun is used only in singular, whereas the term “message” has both a singular and a plural form. Admittedly, a disadvantage of such approach to the term “information” is that it is not compliant with the grammar of the Polish language and the common communication practice.

The tools of communication are man-made natural (e.g. national) languages and artificial (e.g. machine) languages. Due to the diversity of the subject and methodology of research also within particular academic disciplines appropriate languages are created and used, basing on natural languages. Languages are used to encode information. It is easy to notice that information represents the reality and language represents information, which is illustrated in the following chain of dependencies:

\[
\text{reality} \rightarrow \text{stimuli, signals} \rightarrow \text{entity} \rightarrow \text{information} \rightarrow \text{language} \rightarrow \text{communication}
\]

Each language is a system of symbols equipped with certain semiotic properties (semantic, syntactic and pragmatic), performing two fundamental functions:

- cognitive (model), making it possible to create, record and store informational representations of objects.
- communicative, making it possible to convey information in the form of messages and enabling entities to communicate.
Efficient performance of these functions conditions, for example, a uniform and accurate semantic convention, ensuring the greatest possible *similarity of concepts* in the sender and in the recipient of information encoded and conveyed in a given language. The syntactic aspect of a language concerns the logical composition of systems of linguistic symbols forming syntactic structures (e.g. words in a sentence, sentences in a text). The pragmatics of language determines relations existing between the sender and the recipient of information and the symbols of a given language which they use. Semiotic issues, and especially semantic issues, are an important and yet underdeveloped component of the theory of information and qualitology.

Processes and products are externalized (verbalized) in the form of different languages created by human. Each language makes it possible to create, store and convey information in the form of concepts. Thanks to these possibilities – the resources of information on the reality are created and used in human activity.

A kind of simple linguistic signs used in human communication are verbal signs: parts of speech, parts of sentences, words, names, terms, etc. from which complex signs are constructed – expressions, phrases, sentences and more complex content structures. What has a special meaning is terms, i.e. words or phrases which have been conceptually defined. Fundamental signs of a language are letters, figures, punctuation marks and graphical marks, etc. In the case of the so-called body language – its fundamental signs are appropriate body posture and the appearance of the speaking person (i.e. his or her gestures, positions of parts of his or her body, mimics, dress).

Encoded information – recorded and conveyed with the use of a given language in the form of messages – is related to a particular *material medium*. Recording information on a material medium involves its proper forming. This forming takes place as a signal (a general stimulus) which, affecting sensory organs of the recipient, provides him or her with information compliant with the common convention of the sender and the recipient. The uniformity and accuracy of a semiotic convention are attributes directly influencing the effectiveness of communication. These attributes are at their best in a situation when the sender and the recipient are a single entity.

In a general approach, communication is a multi-subject net of complex activities composed of many varied and related elements. In a unitary approach, communication takes place under the name of a *communication process* illustrated by the conveying of a message from the sender to the recipient. The scheme of such process is presented in Fig. 1.1.

A concrete form and interpretation of some elements of the communication process depends on applied technology of communication concerning for example the channel (net) through which signals are conveyed. One of the conditions for the efficiency of the communication process is the compatibility of the languages of the sender and of the recipient, including the compatibility of
their semiotic systems and conceptual thesaurus. If a message is encoded in one language and decoded in another it requires an appropriate linguistic translator. Using a translator increases the risk of the lack of compatibility between the message sent and the message received.

In the theory of information we often encounter the term “data” which however has not been clearly defined. In the terminological convention adopted in this Chapter, data represent appropriately structured information which occurs in the process of information processing. The input of this process is data (input information), whereas the output is the result information (output information). The following definition of the term “data” is proposed:

**Definition 8. Data are messages aimed for processing.**

In a situation when machine processing is used, data must be encoded in a machine language on a particular medium, and entered through input devices in the form of signals to the machine. The physical form of signals enables their reception and programmed transformation in processing devices of the machine. The processed signals reach the output devices where they are decoded and presented in a language understood for the recipient.

An important category in the theory of information is knowledge [Flasiński, 2011; Wrycza, 2010; Kisielnicki, 2008; Materska, 2007; Olejniczak, 1989; Papieska-Kacperek, 2008]. Knowledge arises as a result of mental operations of data processing supported by machine operations of data processing (e.g., extracting knowledge from data). These are, among other operations, operations of interpretation, transformation, analysis, synthesis, conclusion and synergy. The result of these operations is general information – universal and up-to-date in a relatively long period of time, concerning laws, regularities and rules existing in the reality. Hence, knowledge occurs as a special kind of information. The essence of this term is expressed in Definition 9:

**Definition 9. Knowledge is information on permanent relations existing in the reality (laws, rules, principles, dependencies, patterns, etc.).**

From the presented author’s terminological approach it occurs that the fundamental category in the theory of information is the concept of information. All the other terms have been defined on its basis. Unlike in the case of many approaches to be found in literature, the concepts of such terms as communication, message, data and knowledge include the concept of information.

1.4. Similarities and differences between the categories of quality and information

The presentation and analysis of the place of the category of quality in qualitology included in sub-chapter 1.2 and of the category of information in the
theory of information in sub-chapter 1.3 constitute a sufficient basis for the preparation of an initial description of similarities and differences between these categories. The description applies only to these concepts of the categories of quality and information which have been developed by the author of this chapter.

From the comparative analysis of the definition of terms “quality” (Definition 1) and “information” (Definition 6) a conclusion may be drawn which is at the same time the most important attribute of similarity between the two terms – that quality is one of the forms of information. Therefore, information in relation to quality is a more general term, encompassing other terms and superior to them, whereas quality in relation to information is a more detailed term, of a smaller scale and inferior. Hence, the concepts of information and quality differ with respect to the states of the following attributes: level of abstraction, the extent of the meaning and hierarchy. Bearing in mind the aforementioned statements modified as a result of taking into account the superior concept of information, the definition of quality is:

**Definition 10.** Quality is information in a form of a set of attributes.

The term “attribute” used in Definition 10 may be understood as elementary (unitary) information.

As it is apparent from the above reflections, (sub-chapter 1.2 and 1.3) the concepts of information and quality belong to each known or created element of the reality (object) and are mental images (abstracts) of the objects made as a result of cognitive or creative operations. Both information on an object and the object’s quality are limited only to information and attributes characterizing a given object. Hence, the following definitions:

**Definition 11.** The information on a object is the information belonging to it.

**Definition 12.** The quality of an object is information in a form of a set of attributes belonging to it.

From the comparison of Definitions 8 and 12 it arises that both information on an object and the quality of it are conveyed in the form of messages in the process of communication.

If the concepts of information and quality may represent any object, they may also represent the following terms: information, quality, information on the object and the quality of the object. Therefore, the following expressions are acceptable: the quality of information, information on quality, information on the information on an object, the quality of information on an object, information on the quality of an object, the quality of the quality of an object. A more detailed description of information presented in the form of an attribute equals the states of the attribute.

As it is shown in sub-chapter 1.3, a special subject of research in the theory of information is the quality of information. An important task in this research
is developing a set of important attributes of information characterized with a high level of substantial (taking into account the diversity of information) and objective (taking into account the diversity of objects to which it belongs) universality. To such attributes of information belong, among other, the following attributes: immateriality, authenticity, objectivity (subjectivity), quantity, accuracy, timeliness, complexity, consistency, comprehensiveness, detail, value, usability, clarity, divisibility, durability, sustainability, innovation, diversity, mobility, relevancy and reliability. The same attributes apply also to quality which corresponds to the term of the quality of quality.

A set made of important universal attributes of information is called the common quality of a set of separated fragments of information. In the general approach, separating fragments of information is done in relation to separating from the reality objects to which certain fragments of information belong. As a result, we can talk about the common quality of the fragments of information which belong to the elements of a given set of objects (data, messages, signals, events, facts, processes, phenomena, things, etc.). The common quality is composed of those and only those attributes which belong to all the elements of the set. Each element of the set may be characterized also by individual attributes, which – together with the common attributes – create the quality of these elements (e.g. the quality of data, the quality of messages, the quality of signals, the quality of stimuli).

The set of important universal attributes of information includes also the attribute of the value of information. The attribute stems from the relation existing between an entity and information, showing the impact of information on the satisfaction of needs, achievement of goals and meeting the requirements of an entity. The designates of the attributes of the value of information may reflect psychological, economic, ethical, aesthetical, social, ecological, physiological and other values. The operation of assigning value to a piece of information involves choosing the right designate (or designates) of the value attribute of information and assigning a certain state (or states) of this designate (designates) to this fragment of information. Assigning value to information in a form of an object is explained in section 1.2 (Definition 3).

The set of important universal attributes of information includes also the attribute of the quantity of information. Hence, this attribute belongs also to each fragment of information, e.g. a message. This also means that to each fragment of information a certain state of this attribute belongs. Therefore, in order to use this attribute, we must first develop appropriate measurement scales for the quantity of information.

The mathematical method of measuring the amount of information mentioned in section 1.3, based on the likelihood of events and entropy, is concentrated on just one aspect and insufficient. The lack of other sufficiently developed methods of measurement means that it is a complex and difficult issue. The postulated direction of searching for the scales to measure the amount
1. Comparative analysis of the category of quality information

of information involves using a number line to represent the number of signs of a language (letters, figures, words, sentences, paragraphs, pages, graphical signs, volumes, etc.) used to encode a given fragment of information after eliminating redundancy. The use of such measurement scale means that an amount of information included in the quality of an object is determined by the power of a set of attributes. Such measurement is definitely imperfect and relative. These shortcomings are mainly due to the diversified information capacity of signs and the diversified structure and form of the used languages. However, even such imperfect measure of the amount of information can be useful in fulfilling the cognitive and communicative functions of a language.

Communication includes extremely important operations of encoding and decoding of information with the use of language as a tool (Fig. 1.1). The efficiency of using this tool depends on the quality of the semiotic system. Hence, the selected information-quality aspects of the semiotic system of a language will be the subject of the reflections presented further (see: Mantura, 2010, p. 161-163).

The possibility of creating and storing in memory the holistically approached images of objects in the form of quality, which by means of a semantic function are subjected to certain signs of a language, as well as the capability of conducting mental operations on these images – constitute the original mechanism of learning about the reality and of human’s creative work. An ability to perceive objects and create mental products corresponding to them, as well as the necessity to communicate are responsible for the need to create individual (unitary) names, assigned to particular objects and general names, assigned to sets, classes, kinds and groups of similar objects. Hence, an individual name has one and only one designate, whereas a general name has at least two designates.

In every language, names belong to an especially important class of signs. A semantic basis for the creation of a general name for a given set of similar objects constitutes their common quality \( J_w \), which determines at the same time the concept of this name: general name \( \leftrightarrow J_w \). Therefore, each general name is a sign of a language which – having been received – should evoke in the mind of the recipient association with the common quality of a given set of objects.

The collection of all objects identified with a given general name is an adequate set and at the same time the scope of this name. A condition sufficient for the belonging of a given object to the scope of the general name is that the common quality \( J_w \) is included in the quality of this object \( \left( J_w \subseteq J_p \right) \). In a situation when \( J_w \not\subseteq J_p \), the object is not within the scope of a given general name.

If there is a need to linguistically distinguish objects tagged with a given general name, a set of individual names should be created. A semantic basis for the creation of individual names are the qualities of particular objects of a given
set. While creating a notion corresponding to the individual name, a reference should be made to the general name which identifies common quality $J_w$ and individual quality $J_i$, as a complement of the common quality to the quality of this object $J_p$. The total of the common quality and individual quality is the quality of an object and at the same time a notion corresponding to a given individual name: the individual name of the object $\rightarrow J_w \cup J_i = J_p$. Hence, each individual name is a sign of a language which – having been received – should evoke in the mind of the recipient an association with the quality of a given object.

The presented semantic idea is aimed (among other goals) at information and quality standardization of terminology, involving a clear assignment of particular general or individual names (terms) of a given language to appropriate common qualities of the determined sets of objects or qualities of particular objects of these sets. This can be done with the use of semantic quality function $F_s$ whose general formula is as follows:

$$F_s : Z_s \rightarrow R_j$$

where: $Z_s$ – the collection of the signs of the language.

Semantic problems in everyday language are resolved on the basis of a long tradition, routine and practice, based on the intuitive understanding of the meanings of language signs and language syntax. As far as a scientific language is concerned, the extent of semantic standardization is usually much higher, although it concerns only key terms of a given academic discipline. In many academic disciplines, there is a visible lack of agreement in defining these terms, which results in the individualization of terms and decreases the efficiency of communication.

The decrease in the efficiency of communication results in three linguistic situations. The first situation involves the introduction of new terms, applicable only in the field of a given academic discipline, which results in a hermetic discourse, the isolation of the discipline and a decrease in the systemic cohesion with other academic disciplines. The second situation involves the assignment the same terms to different concepts, which results in conceptual ambiguity. The third situation takes place when many different names are assigned to the same concepts, which results in the redundancy of names and the hypertrophy of the language forms over the language’s communicative function.

The conducted comparative analysis of the categories of quality and information shows that they are to a large extent similar. This Chapter characterized not only these similarities, but also features differentiating these categories. Apart from that, the Chapter presented also the place and role of these categories in the processes of communication and in the semiotic system.
2. Prospects for the development of mobile devices based on the use of GPS

ANDRZEJ JASZKIEWICZ

2.1. Introduction

The market of mobile devices based on the use of GPS is developing dynamically. This chapter shortly presents the relevant market trends along with the prospects for the development of the aforementioned devices. The chapter presents data, market forecasts, and research directions. It particularly analyses the applications of the GPS technology in mobile devices, prospects for development of mobile devices (smartphones in particular) and tendencies concerning services and location-based applications.

2.2. Tendencies in the development of GPS devices

The GPS (Global Positioning System) was created by the US Department of Defense, originally for military purposes. Since 2000 the system is widely accessible for non-military use. Therefore, the interference which was previously used to limit the precision of positioning by civilian devices to approximately 100 m is no longer employed. The system covers the entire globe and currently consists of 31 satellites\(^1\). The method of positioning is based on comparing the times of arrival of signals from at least four satellites.

Only a couple of years ago, GPS devices were associated mostly with expensive devices for car or tourist navigation. At present, GPS modules are getting less and less expensive and are installed in more and more devices. No longer are these only navigation devices – now GPS modules are installed also in cameras and, first of all, in mobile devices such as smartphones and tablets. Due to its insignificant impact on the price of the final product, a GPS module is now a standard feature even in the cheapest smartphones.

According to the Bharat Book Bureau, the market of devices equipped with GPS is growing at 20% a year, and in 2013 as many as 900 million of such devices will be sold [Vaughan-Nichols, 2010]. As can be seen, the GPS technology is becoming widely accessible. The increase is to a large extent the result of the growing sales of smartphones and the fact that their users are more and more in-

\(^1\) http://www.idc.com/getdoc.jsp?containerId=prUS23543712 (DOA: August 2012).
interested in applications that can be used in these devices – such as maps, navigation and location-based shopping.

The GPS system does not obviously make it possible to determine the position with every accuracy. The accuracy of positioning in the GPS system and other similar systems depends on several factors [Grewal, Weill, Andrews 2007]:

- the ephemeris error, i.e. erroneous data concerning the location of satellites transmitted by PGS satellites; the data are calculated with the use of the “inverted” GPS algorithm, and therefore fundamentally wrong; they are also updated more or less every two hours, so for most of the time they are only predictions of the location;
- the satellite clock error; although satellites are equipped with atomic clocks, this factor still significantly affects accuracy;
- tropospheric and ionospheric errors affect the velocity of radio waves;
- multipath propagation; a signal reaching the GPS receiver may have not travelled to it the simplest way but even if it has been reflected, it may still be treated as a valid GPS system.

It appears that the installation of PGS modules in mobile devices with access to the Internet creates additional possibilities which make their work more efficient. It is possible thanks to the use of data shared by a mobile network. Such solution is called Assisted GPS or AGPS [Chan, Baciu, 2012]. A GPS receiver may receive from a mobile network such information as: the current time, the positions of base stations which allow to approximately determine the position of the device and facilitate the calculation of the exact position, and also information on the positions of satellites on the sky (the so-called almanac), their theoretical ways and deviations from them (the so-called ephemeris). The main aim of the GPS technology is to reduce the time of the first positioning. This also means lower use of energy and reduction of costs of the GPS module itself, as such module may be simpler than a separated device of a similar quality. AGPS is currently widely used in mobile devices.

Although the term GPS is now used as a synonym for satellite navigation, the system the name refers to – the one constructed by the USA – is no longer the only solution of this type. Among the ones worth mentioning are: the Russian GLONASS (Global Navigation Satellite System), the European GALILEO of the Chinese Beidou. One tendency in the development of navigation modules involves the use of signals from more than one navigation system [Kos, Grgic, Sisul, 2006], [Mendizabal et al., 2009]. This brings users certain benefits – such as shorter positioning time, better accuracy and noise immunity thanks to the use of signals from a greater number of satellites.

It is worth mentioning than satellite navigation is not the only way of positioning widely used in mobile devices. Positioning can also be based, for example, on the mobile network itself [Kos, Grgic, Sisul, 2006]. The simplest and
most often used solution involves the use of the position of a base station to which a mobile device is logged. However, this type of positioning is relatively imprecise. In practice, a typical accuracy is several hundred meters in cities and even more than ten kilometers outside cities.

Another way of positioning without GPS is based on Wi-Fi networks. This method ensures better accuracy – from several dozen to several meters – under the condition that there is a Wi-Fi network of a known position around.

In some applications, the accuracy of such alternative positioning methods is completely sufficient. For example, in the case of weather forecast or urban information services it may be enough to determine in which town the user is. Positioning methods without GPS have such advantages as quick positioning time, energy saving and the fact that they may be applied also in places where no GPS signal is accessible, e.g. in buildings.

2.3. Prospects for the development of mobile devices

The sales of modern telephones equipped with operating system which allow to install additional applications, i.e. the so-called smartphones and tablets are growing all over the world. Such devices are no longer just phones – they have become universal, multi-functional, handheld computers with internet access.

According to one definition, a smartphone is a portable telephone device which integrates the functions of both a handheld phone and a handheld computer. A smartphone is not just another gadget. The appearance of smartphones has been one of the most important technological events of the last years. Although many of us are not aware of this fact yet, smartphones change many areas of our lives, e.g. entertainment, shopping, marketing and social networking. Smartphones’ unique capabilities arise from the combination of the following features:

- large computational capabilities and large memory; modern smartphones are powerful computers, their capabilities are only slightly worse than those of the latest PCs and far beyond the capabilities of similar devices constructed a few years ago;
- convenience and constant availability; unlike a computer user, a smartphone user has the device on him almost all the time; a relatively small device fits in a pocket and is always on, so can be used at any time;
- constant internet; a mobile network provides continuous access to the cloud; smartphones can easily make use of even faster wi-fi network in places where it is available;

comfort of using; although devices called smartphones had been known for the last twenty years\(^3\), the key to their popularity was the development of special (and not simply transferred from PCs) graphic user interfaces operated through convenient touch-screens;

- equipping them with a number of sensors increasing their capabilities, and first of all – equipping them with GPS receivers;
- easy access to additional applications. Users of modern smartphones can shop for applications and choose from among thousands of free or paid programmes directly from their devices.

According to the IDC company\(^4\) in 2012 as many as 686 million smartphones will be sold in the world, which translates into a 38.8 % share in the sales of mobile phones. According to the GfK Polonia company the situation in Poland will be similar – in January 2012, the share of smartphones in the sales of all mobile phones was 37% (in January 2011 – 20.5%). According to GfK Polonia\(^5\) the most popular providers of smartphones in Poland are: Samsung (42.5%), Nokia (19.7%), Sony Ericsson (18.6%) and HTC (10.6%). Specific for the Polish market is a relatively low share of Apple’s iPhones, the global sales of which was about 20.5% in 2012\(^4\), whereas in Poland it was only 3.5% (according to GfK). However, this data concerns only the official sales and does not include individual import. Almost all (98.3%) smartphones sold in Poland in January 2012 were equipped with GPS.

At the same time, the sales of tablets – devices in many respects similar to smartphones but with larger screens – are also growing. Moreover, the difference between smartphones and tablets is not clear – a good example of which is Galaxy Note 5\. According to analysts from the IDC company\(^6\) as many as 107.4 million tablets will be sold in the world in 2012 and in 2016 – 222.1 million.

An increase in the interest in smartphones and tablets is strictly related to the development of mobile operational systems which make it possible to conveniently use the capabilities of these devices. Over the last years much has changed on the market of operational systems for smartphones [Gavalas, 2011]. This is related mostly to the rapid growth in the interest in the Android system, while at the same time the popularity of Symbian and BlackBerry OS is declining. IDC\(^4\) predicts that the share of the Android system on the market of

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\(^3\) http://www.gfk.pl/ (DOA: August 2012).


smartphones will reach 61% in 2012. The next will be the iOS system of the Apple company (20.5%). Despite the unfortunate beginning of the Windows Phone system (5.2% in 2012), IDC analysts predict that the share of this system will increase significantly (up to 19.2% in 2016). At the same time, by 2016, the share of the Android system will decrease slightly but remain dominant, with 52.9% in 2016, while the iOS is to maintain its stable position (19% in 2016). These three systems are to dominate the market of mobile operational systems in the years to come, naturally, as long as there is no new initiative to compete against them. What is important, all these systems require the installation of a GPS module in a device. They all support also other methods of positioning, e.g. with the use of a mobile or Wi-Fi network.

Very similar forecasts concerning the popularity of mobile operational systems are presented by the Gartner company\(^7\). The analysts of this company predict that in 2015 the market will be dominated by Android (48.8%), followed by Windows Phone (19.5%) and iOS (17.2%). At the same time, they predict the disappearance of Symbian and BlackBerry OS, and in the long run – also Samsung’s Bada system.

GfK Polonia\(^8\) informs that in January 2012 the most popular operational system in newly sold smartphones in Poland was Android (66.8%); Symbian was still quite popular (19.5%), followed by Samsung’s Bada.

The variety of operational systems for mobile devices is naturally a difficulty for the creators of applications, especially if the systems differ not only at the API level but even require the use of concrete programming languages. On the other hand, this variety may not be perceived only as a negative phenomenon. The fact that neither of the systems is a monopoly is positive for users, as it induces competition and development of these products. An interesting direction facilitating the development of universal applications and mobile services is the standard HTML 5 proposed by the World Wide Web Consortium [Vaughan-Nichols, 2010]. The capabilities of this standard make it possible to create applications comparable to native mobile applications, including using the user’s location. Currently, we are witnessing a rapid development of mobile browsers for compatibility with HTML 5.

As it has already been mentioned, modern smartphones and tablets are multifunctional computers with internet access. Their specificity involves also the presence of a number of factors increasing their capabilities, such as: accelerometer, gyroscope, digital compass, proximity sensor, light sensor, microphone, camera, and most of all GPS [Bahl, Padmanabhan, 2000]. Additionally, thanks to Bluetooth or Wi-Fi links, it is easy to use external, specialized sensors. Some of these additional sensors may facilitate positioning. For example, accelerator-
Andrzej Jaszkiewicz

...gyroscope make positioning possible also in places with no GPS signal, e.g. in tunnels or buildings [Lukianto, 2010].

Mobile devices are so convenient that they can be used not only for car or tourist navigation but also inside buildings, e.g. in shopping centers. Unfortunately, the GPS signal is easily absorbed by walls of buildings. Much is currently done to solve this problem. The proposed solutions include the use of these already mentioned additional sensors of mobile devices [Lukianto, 2010] or positioning with the use of the Wi-Fi network. It can be expected that in the future mobile devices will provide nearly the same quality of positioning indoors as outdoors.

2.4. Location-based services

The widespread availability of smartphones and tablets makes it possible to offer users a number of mobile services, including location-based services. It works both ways: the availability of these devices stimulates the development of the market of mobile services, and the demand for these services increases the demand for the devices. Analysts predict further dynamic development of location-based services, which will involve the increase in the revenues in this sector. Bharat Book Bureau predicts that in 2013 the global revenues from such services will reach the level of 10 billion dollars [Vaughan-Nichols, 2010]. Pyramid Research’s forecast is a bit less optimistic. According to this company, the global revenues for location-based services in 2015 will reach 10.3 billion dollars, which means increase in comparison with the amount of 2.8 billion dollars in 2010. These revenues will be generated mainly by navigation services. The actions of Google and Nokia change the model of generating revenues from navigation services from the Premium one to the advertising one, in which the service is free for the user. Another company, IE Market Research Corporation, predicts that in 2016 the revenues in this sector will reach the amount of 15.2 billion dollars, with annual growth at 22.7%.

The popularity of mobile services is strictly related to the development of mobile applications. Over the last years, significant changes have taken place in this field. While several years ago it was mobile operators who had the dominant position in this field, at present, the market is dominated by the following companies: Apple and Google [Grewal, Weill, Andrews, 2007]. These companies organized easily accessible stores with applications (iTunes and Google Play) from which users may download free and paid applications.

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Many of the most popular mobile applications are based on using the user’s location. For example, as of 13/08/2012, the list of the most popular applications in the Google Play store included the following applications of this type:

- Endomondo Sports Tracker PRO – an application to collect and share data on training sessions,
- Automapa – car navigation,
- WeatherPro – an application providing information on weather,
- Locus Pro – tourist navigation,
- Mapy – Google maps,
- Street View in Google Maps,
- jakdojade.pl – a public transport route planner.

As can be seen, the range of areas in which applications of this type can be used is very wide and includes sports, tourism, weather information, local information, maps, car navigation and public transport. More and more often new possible applications are mentioned, such as augmented reality [Jung et al., 2012; Mendizabal et al, 2009] or location-based marketing [Chen, Hsieh, 2012].

2.5. Conclusion

Recapitulating, the most important trends in the development of mobile devices based on the use of GPS are:

- the wide accessibility of universal mobile devices of high computing capabilities and offering internet access, portability, ease of use, access to thousands of applications and positioning; this accessibility will become the basis for the development of numerous new applications for mobile devices;
- the high quality of positioning; positioning will be available nearly immediately; it will also be possible in places where at present no GPS signal is available (e.g. indoors);
- further development of services / applications based on the use of the capabilities of mobile devices with location function; we should also expect that in the future the currently known areas of use will develop, while at the same time new applications will appear and become popular.

Thanks to location-based services, a mobile device becomes a part of the real world. Therefore, the sharp boundary between the real world and the virtual one, typical of traditional computers, is now blurred. A user may use its device to see information (and advertisements) related to his current location and at the same time have access to the vast resources available on the internet.
3. Satisfying information needs in “The integrated support system for access to information in urban space”

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3.1. Information needs in the system of needs of the acting entity

Satisfying needs has an impact on the quality of human life [Szafranski, Golisci et al., 2009]. Needs divide into various categories, among which information needs stand out as important. Information means resources which are at the start of any action taken by an entity that wants to achieve a goal associated with a real result of its action\(^1\). Hence, an acting entity needs information which is necessary to ensure the effectiveness and efficiency of its actions. Each entity can act as follows:

- share (provide) information,
- produce or process information,
- acquire information.

Figure 3.1 shows an exemplary relation between three entities, one of which is the main entity in this system.

In order to simplify the example shown in Figure 3.1, some activities performed by secondary entities, as well as the fact that provider acquires information and recipient shares it, have been omitted.

The acting entity’s needs may be divided into those related to the way in which information is acquired and shared (provided) and those related to possessed information.

Acquiring and providing information can be presented using process approach, highlighting the processes \( P_P \) and \( P_D \) as in Figure 3.1. If the processes are to function in an organized way, they must be preceded by planning. Therefore, the plans \( P_P' \) and \( P_D' \) correspond to their matching processes.

The information \( I_u \) acquired as a result of the corresponding process gains characteristics that distinguish and differentiate it from the original information from before the process of acquiring \( (I_u') \). \( I_u \) may differ from \( I_u' \), if it becomes

\(^1\) The relation between the action, the goal and the real result of the action was already defined by the author of this paper in [Szafranski 2006 and 2007].
distorted owing to disturbances that may occur during the process of acquiring information \((P_P)\).

The acting entity can possess information \((I_p)\) which it either acquired or produced \((I_w)\) on its own, using its own data or original information, as well as some knowledge.

![Diagram](https://via.placeholder.com/150)

**Fig. 3.1. Basic categories of information in the relation between information provider and recipient.**

Own work

Part of the information possessed by the entity, either acquired or produced, can be shared with other entities in either a purposeful or unintentional way. This is the information to be provided \((I_d)\), which becomes distorted and transformed into \(I_d'\) owing to disturbances that affect the process of providing information \((P_D)\).

Not only does an individual or a community notice benefits arising from the acquisition or possession of information for their own purposes related to the possibilities of reaching their own goals, but also benefits arise from sharing information with other entities if – in the opinion of the individual or the community – this may contribute to the achievement of their own goals.

Like any object of recognition, information has certain features that determine its quality. Each type of information and each type of information flow process shown in Figure 3.1. has a certain quality. Table 3.1 presents different types of information and their flow processes with their corresponding dimensions of quality.
Table 3.1. Information and information flow processes along with their quality

<table>
<thead>
<tr>
<th>Information / Information flow process</th>
<th>Information symbol</th>
<th>Quality symbol</th>
<th>The quality of the information / The quality of the information flow process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information to be acquired</td>
<td>I_u'</td>
<td>Q_u'</td>
<td>the quality of the information to be acquired</td>
</tr>
<tr>
<td>Acquired information</td>
<td>I_u</td>
<td>Q_u</td>
<td>the quality of the acquired information</td>
</tr>
<tr>
<td>Produced information</td>
<td>I_w</td>
<td>Q_w</td>
<td>the quality of the produced information</td>
</tr>
<tr>
<td>Possessed information</td>
<td>I_p</td>
<td>Q_p</td>
<td>the quality of the possessed information</td>
</tr>
<tr>
<td>Information to be provided</td>
<td>I_d</td>
<td>Q_d</td>
<td>the quality of the information to be provided</td>
</tr>
<tr>
<td>Provided information</td>
<td>I_d'</td>
<td>Q_d'</td>
<td>the quality of the provided information</td>
</tr>
<tr>
<td>Plan of the process of acquiring information</td>
<td>P_P'</td>
<td>Q_P'</td>
<td>the quality at planning the process of acquiring information</td>
</tr>
<tr>
<td>Process of acquiring information</td>
<td>P_P</td>
<td>Q_P</td>
<td>the real quality of the process of acquiring information</td>
</tr>
<tr>
<td>Plan of the process of providing information</td>
<td>P_D'</td>
<td>Q_D'</td>
<td>the quality at planning the process of providing information</td>
</tr>
<tr>
<td>Process of providing information</td>
<td>P_D</td>
<td>Q_D</td>
<td>the real quality of the process of providing information</td>
</tr>
</tbody>
</table>

Own work.

Figure 3.2 shows the main dimensions of the quality of the information in a provider-agent-recipient relationship presented in an analogical way to Figure 3.1.

Fig. 3.2. The main dimensions of the quality of the information in a provider-agent-recipient relationship. Own work
In regard to the quality of the information possessed by the acting entity one can make the following observations:

(A) Frequently, the acting entity, being in possession of information, will decide whether to share it or not; the same information may be perceived in a different way, depending on the entity’s decision of using it. Simultaneously:
- if the acquired information \( (I_u) \) has the same characteristics as the information to be provided \( (I_d) \), then the sets of their characteristics and at the same time their qualities will be equal \( (Q_{iu} = Q_{id}) \)
- if the produced information \( (I_w) \) has the same characteristics as the information to be provided \( (I_d) \), then the sets of their characteristics and at the same time their qualities will be equal \( (Q_{iw} = Q_{id}) \)

(B) If the set of characteristics of the information is extended by its value, then, depending on the purpose of the information, the same information may have – from the acting entity’s perspective – different quality; for example, the quality of the acquired information \( (I_u) \) may be different from the quality of the information to be provided \( (I_d) \), i.e. \( (Q_{iu} \neq Q_{id}) \); the acting entity perceives the acquired information in a different way when it does not notice benefits from sharing it and when it notes the added value that flows from sharing it further.

(C) If the quality of the information acquired by the entity \( (Q_{iu}) \), the quality of the information produced by the entity \( (Q_{iw}) \) and the quality of the information to be provided (shared) by the entity \( (Q_{id}) \) are treated as sets of characteristics, then the sum of these sets will constitute the set of characteristics of the possessed information \( (I_p) \), i.e. the quality of the possessed information \( (Q_{ip}) \):\

\[
Q_{ip} = Q_{iu} \cup Q_{iw} \cup Q_{id}.
\]

between \( Q_{iu}, Q_{iw}, Q_{id} \) treated as sets of characteristics there may be common parts, i.e. one characteristic can belong to more than one set, as presented in subsection A).

3.2. Needs for information about objects in urban space

One category of information needs (the meaning of which is growing rapidly) is needs for information on objects in urban space. Although usually under the notion of urban space we understand all public spaces which can be used by citizens free of charge, i.e. roads, pavements, squares, parks or public utility buildings, where the owner of urban space is usually the state and the supervision is held by a local self-government body [Gotlib et al, 2007], from the perspective of citizens or people temporarily staying in urban space the understanding of this notion should be extended to include places and objects which may be used against payment (cinemas, products, services, etc.).

In this paper, the notion of an object is understood very broadly – as each event or state in urban space (its whole or its part) the acting entity wants to enter
3. Satisfying information needs in “The integrated...

into a relationship with, or has entered into a relationship with, seeing benefits from keeping this relationship involving facilitating the achievement or direct achieving of goals of this entity, or to the contrary – if the entity does not want to enter into a relationship with an event or state, judging that maintaining this relationship would negatively affect the achievement of the entity’s goals. In this context, the objects of urban space will include both a pharmacy and medicine sold there, a car park, a hole in a road, a charity clothes collection point, a church, a mass, a historic sculpture in the church, a concert, a traffic jam, etc. Understood in this way, each object will have both its inherent and assigned characteristics (e.g. height, value, duration time, geographic location, existence time, color, etc.) and each of these characteristics will assume different states within their variation range.

The systems of information about objects in urban space become more complicated along with the increase in the complexity of:
- the urban space,
- the system of information needs of entities staying in this space.

One of the factors leading to the development of urban space is the increasing number of urban citizens.

The increasing number of urban citizens results in the increasing variety of their needs. It is one of the factors responsible for the increase in the interest in information about objects in urban space. Another factor is the lifestyle of citizens, especially in big cities, as – in comparison to the inhabitants of villages and small towns – they spend most of their time out of homes and, living an active life, more often seek information about objects in urban space. It is therefore necessary to take measures to provide system solutions supporting access to information in this field. Such access to information makes life in a city easier, increases the quality of living of both the inhabitants of cities and people temporarily staying in them.

A team from the Poznań University of Technology has developed a system addressed mainly to those seeking information in urban space, thus contributing to increasing the level of $Q_{ia}$ (the quality of the information to be acquired), $Q_{iu}$ (the quality of the acquired information), $Q_{pp}$ (the real quality of the process of acquiring information). It is called “The integrated support system for access to information in urban space”.

3.3. More about “The integrated support system for access to information in urban space”

“The integrated support system for access to information in urban space” is both the name of a project and a solution developed as part of this project. The project was started in 2010 at the Poznań University of Technology (Politechnika

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For more about characteristics and their states see W. Mantura (Mantura, 2010).
Poznańska) as a developmental project funded from the National Centre for Research and Development (Narodowe Centrum Badań i Rozwoju). It is one of a group of projects under the common name of the Acceleration of Technological Knowledge (Akceleracja Wiedzy Technicznej®) aimed at implementing the assumptions included in “The program for the acceleration of technological, mathematical and scientific knowledge in Poland” [Szafrański, Grupka, Goliński, 2008]. More information about the program and the project in the context of the program implementation may be found at [www.awt.org.pl](http://www.awt.org.pl).

The aim of the work undertaken as part of the project was to create a product to seek information in urban space using GIS (Geographic Information System) and GPS, in order to ensure the quality of information and an ergonomic interface capable of satisfying the expectations of the system’s users. A pilot solution has been developed for the city of Poznań but it is an open project, which means that it can be developed and implemented in a large area. The following users are distinguished in the system:

- city’s inhabitants,
- incomers, including tourists.

During the preparation stage of the project [Szafrański, Goliński et al., 2009] it was noticed that, at least in the considered geographic area, the knowledge about the informational and utilitarian needs of potential users of geolocation systems is incomplete, as a result of which only a limited number of citizens use mobile devices to search for objects in urban space. The largest institutions, including local self-government institutions, do not have comprehensive knowledge about the citizens’ information needs. As far as commercial companies are concerned, they must quickly launch onto the market solutions acceptable for users; therefore, even if there is a number of solutions making it easier to use software and enabling users to search for objects in urban space, they are not implemented. Especially micro and small IT enterprises operate based on an idea of a simple product, which is then quickly placed on the internet to be, hopefully, noticed by potential users.

In this context, during the project it was considered important to focus on developing reliable methods of constant improvement of the quality of information and of the ergonomics of using it in systems supporting access to information in urban space, so that the use of developed solutions was able to significantly influence the improvement of the quality of life [Goliński, Szafrański et al, 2009].

The project includes seven tasks:

1. The analysis of the needs of the system’s users in terms of information and service, as well as the importance of these needs.

2. The analysis of the possibilities of using the data included in the municipal database (in cooperation with the employees of the Poznań City Office) and the identification of limitations on the use of municipal data in the created system as well as of ways to minimize these limitations.

3. The design of the functionality and the user’s interface.
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(4) The design of an IT subsystem, including the development of procedures and instructions for using it.
(5) The testing of the support system and the extent to which it fulfils the users’ key requirements.
(6) The testing of the IT subsystem.
(7) The development of the final version of the IT subsystem.
(8) The development of the final version of the support system.

Figure 3.1 presents the division of tasks into research and development work tasks. The studies in the project constitute preparation stages necessary to make decisions concerning the organizational and technological aspects related to both the implementation of the project and the solutions to be applied in the project’s product.

![Diagram of research and development work tasks]

Fig. 3.3. The division into research and development work tasks in the project.

Own work

The main product of the project is a system whose name arises from the name of the project. A system means here “selected from reality, a set of interrelated elements constituting the whole whose quality differs from the sum of the qualities of its elements” (Szafrański, 2006). The integrated support system for access to information in urban space includes the following categories of elements:
- actions,
- acting entities,
- tools and materials,
- results,
- relations between the aforementioned elements of the system.

The name of the system emphasizes two of its features: its integrated nature and readiness to support access to information.

Integration is manifested in several aspects of the system:
- the integration of data from different bases, leading to improving the quality of data and ultimately, the quality of information,
the integration within a single system of new computer solutions and solutions already used in other products present on the market, especially in relation to the user’s interface, which leads to the new quality of the process of seeking information about objects in urban space,

- the integration of systems of individuals’ information needs, which may ultimately facilitate not only the analysis of changes in the community’s information needs concerning objects in urban space, replacing the traditional research methods (surveys, focus groups, etc.) and even predicting future information needs, but also facilitate the placement or removal of objects in / out of the city on the basis of the information about the needs and trends in their development,

- the integration of experiences of various institutions and economic entities involved in the development of the system, leading to the integration of competences, including the know-how to create solutions under this project.

The developed system is aimed at supporting decision-making processes and not at making decisions for users, among others, in the following areas:

- locating objects,
- choosing interesting objects,
- finding or avoiding certain objects.

The use of the word “support” in the name of the system was well-thought out. This word is a clear message to users that the product that will be made available to them is to support them in solving problems concerning the choice of objects and finding the right route to objects in urban space, but it will not make decisions for the users of how to function in this space.

### 3.4. The mobile city – a tool in “The integrated support system for access to information in urban space”

One of the elements of the developed system is a tool supporting access to information, called “the Mobile City”. “The Mobile City” is then one of the previously distinguished elements of “The Integrated support system for access to information in urban space”. It is described in detail in Chapter 8 by Tomasz Skawiński.

### 3.5. Mediating functions in “The integrated support system for access to information in urban space” and their automation

People seeking information about objects in urban space may seek them in many ways: on their own, using secondary sources of information, following the information available in the municipal information system or asking passers-by
where to go and how to get there. Finally, they may make use of agents. An offer of this kind is “The Mobile City”, providing that the system to which it belongs is implemented. This causes the necessity of maintaining the tool by employed staff.

“The Mobile City” is an automated agent whose implementation facilitates providing services of interchanging information about objects in urban space.

Automation in this system means limiting people’s participation in the process of servicing the parties interested in interchanging information, which is possible due to the use of such tools as GPS or software, enabling automatic downloading of data from dispersed databases and their conversion into information. Such a solution significantly reduces costs of the system’s functioning. It also allows for manual input of data about objects. This function will be performed by the users interested in sharing information.

Creating a description of the functions of “The Mobile City” tool one may make use of characteristics of the agents derived from the marketing literature, additionally pointing up their specificity resulting from automation. In relation to the fact that the planned process of interchanging information proceeds without transfer of the property right, the closest model to “The Mobile City” is the concept of information broker acting as an agent for information about objects in urban space. Adjusting to the system’s operating conditions to the term of broker defined by P. Kotler [Kotler, 1994], it should be stated that it brings information providers and recipients together. Kotler uses terms ‘buyers’ and ‘sellers’. However, without forming a business model for the service in question one cannot prejudge whether it will be paid or not, thus whether it will be an object of trade or not (indeed, it can be provided as a non-profit service). As in the case of any broker, one will also not take any risk for goods in this system; moreover, it would be difficult to speak of running a warehouse. One may consider the validity of using the term ‘data warehouse’ with reference to a database being created; nevertheless, even if the use of this term were correct, the bases in question belong to a different category of warehouses than those from the field of distribution of goods.

A typical broker does not conduct financial operations. However, in the case of “The Mobile City” such operations would be conducted if the service were provided by an enterprise – an independent business entity.

The main functions of an agent, which may refer to “The Mobile City”, are as follows:

- promotion of the tool, leading to its more frequent use,
- verification of credibility of data and information,
- safe data storage,
- consulting in the field of data input into the system, preparing information on their basis and using the available information,
- preparing information in a way to increase the probability of mutual contact between entities that provide and seek information,
- improving the quality of information, taking into consideration the changing needs of users and the changes in urban space,
- improving the user interface, considering the technological progress,
- performing activities related to tool use that develop users’ technological skills
- data processing, on the basis of users’ information needs.

Fig. 3.5. The process of distributing information about objects in urban space with “The Mobile City” tool as information agent. Own work

Figure 3.5 presents the process of distributing information about objects in urban space, taking into consideration “The Mobile City” tool. In the system, some entities may perform both a function of information provider and information recipient.
4. Methodology of research into information needs

MAREK GOLIŃSKI

4.1. Introduction

The aim of the implementation of the project entitled “The Integrated support system for access to information in urban space” (Mobile City) is to meet the information needs of users of mobile devices getting around an urban area. One of the subject of the project was determining the scope, form and method of presenting the desired information. The relevant research took several years and started even before the implementation of the project itself. It encompassed different research areas and included the following studies:

- the analysis of available secondary sources which could be useful for the project,
- the overview of literature concerning theoretical assumptions related to communication process,
- the overview of other systems available on the market offering similar functions to those of the Mobile City web application,
- exploratory research into information needs of users,
- tests of the ready application.

Due to the developmental character of the project, the research was conducted constantly, with varying intensity and with the use of different research tools in different periods of time.

4.2. Preliminary research based on secondary sources

The first studies conducted for the purpose of the Mobile City project took place before the project application was filed. They concentrated on the use of information by a user of information in urban space. Apart from that, the features of an IT system were analyzed, taking into account the issues of the user-IT system interaction as an ergonomic feature of the system. Also, it was tested what factors influence the quality of life in urban space. In 2009, the results of these studies were included in the following publication: “Chosen systems of access to information and their influence on formation of the quality of life in municipal space”. Also before the application was filed, selected information technologies supporting access to information in urban space were analyzed, with focus on the kinds of information needs, the functionality of the available solutions and the criteria for the
evaluation of these solutions. These works were used in the publication entitled
“A comparison of selected information technologies supporting the access to in-
formation in urban area”.

The project team, as part of its work, regularly and thoroughly discussed any
information having an impact on the conduct of project works. One of the results of
the team’s works included compact studies – unpublished thematic compilations of
information useful in the design process. As part of the team’s works, particular au-
thors have prepared the following materials: Magdalena Graczyk – “The analysis
of preliminary information available in the database of the Poznań City Office „and
“Information and its value in mobile integrated information systems”, Maciej
Szafrański – “The application of the QFD method in designing the integrated sys-

tem supporting access to information in urban space”, Filip Kierzek – “The com-
parison of the features of mobile software providing access information in urban
space”, Wojciech Pele – “The extent of the access to API implementation with
public transport timetables”.

The main research was informatively supported by the implementation of new
project tasks and was strictly related to the objectives pursued in the project. The
most important research areas concentrated around the following issues:

- improving the quality of information about objects in urban space available with
  the use of mobile devices,
- improving the functionality of the use of information related to locating objects
  in urban space,
- distinguishing a set of useful pieces of information related to location and con-
  cerning the improvement in the quality of life in cities,
- integrating functionalities in the already existing systems of collecting and shar-
  ing spatial data,
- analyzing the possibilities of using QR codes for locating and describing objects
  in urban space.

The aforementioned issues were the subjects of a thorough and regular analy-
sis conducted by the project team, whereas research requiring specialist research
tools and technical facilities was – for the sake of efficiency – commissioned to ex-
ternal entities.

If tasks were commissioned to external entities, the project team prepared the
terms of reference based on the assumptions of the application and the analysis of
external information. The desired research methodology was always specified in
detail, including the selection of research techniques, tools, recruitment methods,
methods of conducting the research, as well as studies including the conclusions
and recommendations. The list of persons recruited and taking part in the research
was always verified and approved of by the team and all the materials used in the
course of the research, e.g. questionnaires and scripts, were edited before the start
of the research in cooperation with the research team.
4. Methodology of research into information needs

4.3. Research into information needs and expectations concerning the mobile device interface

Preliminary research conducted as part of the project and aimed at recognizing the needs of users took place in April and May 2011 and concerned the information expectations of users of the system and possible solutions concerning the user’s interface. The preliminary research was conducted with the use of two techniques: qualitative research with the Focus Group Interview method (FGI) on four groups of respondents and quantitative research with the Computer Assigned Telephone Interview method (CATI) conducted on 400 respondents. As it was necessary to use the research facilities in qualitative studies and to reach a large group of recipients in quantitative research, the conduct of the research was commissioned to an external entity. The research was then conducted by a research institute specializing in market and opinion studies – Pentor Research International Poznań Sp. z o.o.

Qualitative research into information needs

The fundamental aim of the qualitative research was to identify categories of information related to urban space for which there is demand among the inhabitants of Poznań and visitors to the city. The general research population included the inhabitants of Poznań and incomers or commuters (e.g., people working or studying in the city). From the general population respondents were selected whose description best corresponded to the description of the system’s potential users. Depending on the kind of the research method, respondents were divided into four groups according to the categories of age and professional status: the youngest (18–20 years), young (20–30), mature (35–50) and a separate category of entrepreneurs aged 25–40. Within these groups respondents were chosen so that 50% of them were men and 50% women. Half of the surveyed used the Internet in mobile devices often, half of them – seldom (occasionally, less than once a month). From the perspective of the diversity of needs and the familiarity with the objects in the city itself, some of the respondents were the inhabitants of Poznań (70%) and some – of the surroundings of Poznań (30%). An important factor characterizing the users of telephones, navigation and applications is their familiarity with technological solutions and a positive attitude to them. Half of the surveyed qualified as people liking novelties (innovators), whereas the other 50% identified themselves as fans of consumer electronic products.

The basic scope of the research concerned a detailed specification of the range of information the most often indicated as desired by people staying in urban environment. The research problem, problem questions, and specific questions were consulted and approved of by the project team. All the focus group interviews were held in a professional studio for qualitative research, their progress was recorded on DVD records, and they took approximately 2.5 hours. The problem questions concerned such issues as: specifying the ways of obtaining information in urban
space preferred by the respondents, the preferred ways of using a mobile device in order to obtain information, the preferred user’s interface in mobile devices, and learning about the respondents’ needs concerning the quality of information and the quality of the user’s interface.

Basing on the words of the respondents, information which may be sought for by the users of mobile applications and which concerns the life of the city and urban space may be divided into the following groups:

- transport and location – information related to getting around in the city, timetables of means of public transport, information on traffic jams, road works and other traffic difficulties, as well as about ways to reach a given destination,
- leisure activities – cultural and entertainment activities (cinemas and theaters, concerts, exhibitions, festivals), sports (sporting events such as games and competitions), tourism (information about historic places, places to visit, hotels), weather (weather forecast),
- services and administration – administrative matters, the applicable law, opening hours and contact details of offices, institutions and services (shops, hairdressers, etc.), information on restaurants, pubs, cafes,
- local – planned investments (housing investments/ investments related to infrastructure, space development projects), advertisements (job market, private lessons, exchange of handbooks),
- hobby – information related directly to free time, including information about the history of Poznań or information related to sports and Poznań sports clubs.

Grouping of the topics of requested information is also related to how often they are sought. Information needs and frequency of searching for certain information was juxtaposed basing on the opinions of the respondents – this is presented in Fig. 4.1.

Knowledge on the respondents’ information needs and their validity – as specified by the respondents themselves – was very precious for the project team and made it possible to plan the structure of the database and potential sources from which to feed it.

Another useful piece of information included differences in information needs depending on the time of the week. The respondents indicated that on working days the most sought information was information related to transport and travel within the city, as well as information related to services and the opening hours of particular shops, pharmacies, etc. In the case of students, the information sought at that time included also culture and entertainment, as students look for opportunities such as cheaper cinema tickets and lower pub prices on weekdays (as opposed to weekends). The information searched for at weekends is mostly needed to plan free time activities, so cultural and entertainment information, as well as weather forecast are among the most desirable.

Another useful piece of information for the team designing the application was different information needs in a week. This may translate into organizational re-
qurements related to the schedule of feeding the database but also - allows to plan the server access load.

Fig. 4.1. Types of information needs and frequency of searching for information. Based on: [The qualitative…, 2011]

In order to analyze information needs, the research respondents were asked about their sources of information in urban space. The internet appeared to be the most popular and the most often used source of information in Poznań. As other sources of information respondents mentioned friends and the local media. The significant popularity of the internet is, however, not associated with reliability. The internet is perceived as the least trusted source. The respondents trusted more the information obtained from their nearest surrounding – friends and acquaintances (Fig. 4.2).

Fig. 4.2. Popularity and reliability of information sources. Based on: [The qualitative…, 2011]
The designed application is an example of an innovative use of a web application. At present, more popular applications are native ones, dedicated to a given platform, whereas the solutions based on mobile sites, despite their smaller share in the market, indicate the direction into which mobile solutions will develop. One visible disadvantage, with slow internet connection, is a slower data transmission rate. Therefore, a significant part of the qualitative research was devoted learning about the plans of the respondents concerning the use of the internet and the telephone in the nearest future.

The respondents declared that at present they use the mobile internet mainly in situations referred to as “emergencies” – when they need to connect the internet fast and have no possibility to use a stationary connection. Such situations take place mainly when they want to locate a place, find out about route directions or check emails, which is important mainly for people whose work requires them to stay in constant touch with their customers and check emails frequently. The group of people using the internet intensively is constantly growing. “In the first half of 2011, as many as 66% of households had a computer and 61% of them also the internet access. Over 50% of all households have constant internet connection, 15% uses mobile access offered by mobile operators”¹. Those people use the Internet in mobile devices in their spare time, communicating with friends, checking emails or simply surfing the internet. There is a group of people who prefer the mobile internet to the “stationary” internet precisely due to its mobility, which makes it possible for them to access it in any situation and at any time. Such people are a potential group of the so-called “heavy users” (regular customers) of the Mobile City application.

The reason for which some people who use the mobile internet only occasionally is the inconvenience of data viewing, related to problems with connection speed and the insufficient technological parameters of devices. Another significant barrier is also the conviction that the price of such connection is very high.

One of the tasks of the project is to integrate data already available on the internet. The conducted research confirmed that there is a need for a guide with comprehensive information concerning the life of the city. Among the main factors characterizing the ideal system, the respondents mentioned a clear form of presented information, brief and concrete content, a good data loading speed (thanks to modest graphics) and the topicality of the presented content.

The scope of the qualitative research involved also the shape of the interface of the application in question. The respondents mentioned that it was important that desired information was presented both in the form of an internet website and an application. A guide in the form of a website was a solution presented relatively more often and preferred by the respondents due to its obvious, natural and more

familiar image. The respondents mentioned the examples of already existing integra-
tors / information portals such as www.epoznan.pl, or www.mmpoznan.pl. Peo-
ple often using the mobile internet on mobile phones were more enthusiastic about
the creation of mobile applications which would offer quicker access to inform-
ation.

The mobile application the respondents would appreciate should be free of the
existing problems of similar applications, including:

- no up-to-date contact details of companies and institutions,
- the accumulation of obsolete and outdated information concerning past events,
- the lack of one place – a portal / website with all the necessary information
about the city,
- no information concerning the practical aspects of getting around the city, such
as parking bikes.

The respondents, apart from indicating problems with the existing information
and forms of its distribution, described also their own preferences concerning the
form of urban information obtained via mobile devices. Their comments concerned
both the form and the functionality of solutions, and among the most frequent sug-
gestions were:

- as far as information features are concerned: concrete, brief, up-to-date,
- as far as graphics is concerned: avoiding “heavy” elements, more text than
graphics, headlines and key words in bold, maps and logos for location, discrete
colors [black and white], a large, clear font,
- as far as the functionality is concerned: no or only a limited number of adver-
tisements, relevant hits, the size of the page should automatically adjust itself to
the screen size.

In the course of the research, the respondents were divided into two groups:
occasional and regular users of the mobile internet. Selected situations and argu-
ments for the frequency of using mobile applications are presented below for the
two groups: (A) occasional users and (B) regular users of mobile applications.

A) The respondents who declared that they use mobile internet only occasional
were usually very pragmatic with this respect. They only used the mobile inter-
net in emergencies, when it was impossible to use stationary connection. They
focused on: obtaining directions / navigation, reading emails or checking the in-
box, or doing a bank transfer. Their reasons for limited use of the mobile internet
were as follows: the inconvenience of mobile devices (a small screen, lim-
ited battery strength), problems with the speed of the connection and its low
quality (frequent disconnecting), insufficient level of technical parameters of
mobile devices preventing the proper display of some websites, faulty operation
of selected applications; the respondents were often convinced of the high cost
of the mobile internet connection, fear poor antiviral protection when connect-
ing from mobile devices and – quite frequently – declared that they were not
used to using the mobile internet.
B) People who used the mobile internet more frequently described a wider range of occasions when it could be useful. Apart from purely practical motivations they mentioned entertainment (social networking sites, YouTube and similar sites, visiting sites in relation to hobbies). Entrepreneurs reported their need for continuous internet access. Among students there were people who declared using the mobile internet while being at the university – during classes or exams. The main reasons for the frequent use of the internet on mobile devices included: the possibility of using免费 internet thanks to the Wi-Fi technology, the conviction that the costs of mobile internet connection were low [in this context, respondents pointed out at Internet service packages, talked about their desire to relieve boredom or about laziness (manifested in reluctance to switch on a stationary computer to check emails), the conviction that some information maybe faster found on the mobile phone than on a computer, as starting the latter takes a certain amount of time.

While asking the respondents about their opinions of mobile solutions, the researchers enquired also about the preferred form of mobile solutions – “a www page” versus “a native app” installed on a smartphone. Respondents expressed different opinions as to the ideal form of a city information guide - their ideas included both guides in the form of a website and an application. The majority of the respondents, however, opted for a website. The respondents’ opinions indicated that this solution is perceived as the most obvious and natural. Respondents identify city guides with Internet websites, such as www.epoznan.pl, or www.mmpoznan.pl Some of the respondents declared, however, that they would prefer an application – these were mainly frequent users of the mobile internet via phones. They indicated that the form of an application had an advantage over an internet website in that it offered a quicker access to data.

A number of ideas can be drawn from the analysis of the results of the qualitative research. Many of them were already designed in the solution and their usefulness was now confirmed by the respondents. Among them are:

- the system of categories and subcategories – the respondents claimed that the city guide website must be as readable, clear and user-friendly as possible; moving within a category would be possible through links – having clicked on a given category the user would be redirected to the list of subcategories and then – the “deeper” content of a given subcategory;
- data selection and personalization – an idea emerged to increase the functionality of the solution through customization and storing of the previous searches, which would result in a quick access to concrete, preferred information corresponding to the needs of the user; users would choose fields and subcategories of their interest and then they would receive information filtered in accordance with their assumptions; the system could store the settings of a given user and every time he logs in – redirect him to the parts and categories he has read the most so far;
application with speech generator – an ideal system should be based on the already existing guides and use source data from services such as gazeta.pl, epoznań, of the websites of offices and institutions; a given piece of information would be searched for by the criteria entered; the user would not have to go through different categories but would be immediately given the information he or she is looking for; the innovativeness of the system would involve the system of location services using a speech generator; at the user’s command, the system would search for places corresponding to a given voice command and located in the vicinity of the user; in the advanced version of the system, it would also show the directions in Poznań taking into account the location of objects which would be of interest for a given user;

the respondents also pointed out the following necessities: a clear interface, minimum graphics, calm colors.

An important element of the qualitative research was the evaluation of the functionality of mobile devices, basing on the respondents previous experiences. The respondents pointed out the following issues:

- the meaning of an operational system in mobile devices – the popularity of the system, the access to applications and the intuitiveness of operation,
- the possibility to easily access social networking portals,
- communication with the use of Bluetooth and Wi-Fi,
- GPS in the mobile,
- the keyboard form – both a touchpad (perceived as more modern) and a traditional built-in keyboard (with keys),
- smartphone operation with gestures,
- voice search, for example while driving a car,
- variable screen orientation – vertical and horizontal.

In the conclusion, the respondents listed their expectations towards a potential phone – the most important desired features:

- a durable battery – about 7 days without charging for talks and 2-4 days for the internet,
- a good processor / operational system to ensure efficient work of the phone,
- a camera capable of taking good quality pictures,
- a good display screen – of sufficient size and appropriate resolution,
- a touchpad and an in-built keyboard / touchpad,
- a good speech synthesizer – so that you do not have to touch the keyboard if it is not necessary,
- a durable case / a thin case – so that the phone does not get damaged easily when it falls,
- Wi-Fi, Bluetooth, calendar, voice recorder, alarm clock, waterproof, slots for two cards.
The comments which the respondents made during the qualitative research became the basic material for developing a set of issues to be included in the quantitative research. Apart from using the results of the qualitative research to form questions for the CATI research, all the respondents’ comments were treated as significant support at the stage of developing functional solutions and organizing the structure of the database for the application.

**Quantitative research into information needs**

The CATI research was conducted on 400 respondents, 55% of whom were individual users, 25% students and 20% entrepreneurs. 65% declared living in Poznań, the rest lived in the city surroundings. Half of the respondents were women, the test sample structure is presented in Fig 4.3.

The telephone surveying was another stage of research conducted as part of the project and the questions asked were strongly related to the qualitative group research. The basic scope of issues discussed in the research concerned the kinds, frequency and places in which the respondents looked for information related to the city of Poznań. The questions included also the use of the internet when searching for information related to urban space, the use of the internet on mobile devices, the respondents’ preferences with respect to the features of desired information. Also, the profile of a GPS user was determined.

The key questions in the research were: the subject of the information sought, the intensity of the information sought and the desired features of information.

The participants of the research usually sought information concerning: transport [timetables of means of transport, routs to given destinations], events taking place in Poznań and directions. Needs related to this kinds of information were...
declared by 68%, 62% and 48% respondents respectively (Fig. 3.4). Another group of information concerned urban topography, including the location of retail and service outlet [also catering points], offices and institutions in the city, centers providing emergency assistance, restaurants, pubs, cafes, promotions and prices, traffic jams in the city, road works and other transport difficulties in the city, as well as the location of historic and simply interesting places in Poznań. Occasionally, respondents declared information needs related to the location of car parking spaces, objects in the vicinity of the place where the information seeker was at a given moment, accommodation addresses, hotels and bicycle paths.

Fig. 4.4. Topics of desired information. Based on: [The quantitative…, 2011]

The internet is the key source of information. Notice boards and friends are much less frequently used as sources of information. A computer is still the most popular device used to seek information on the Internet. Mobile devices are used definitely less often [every third student, every fifth individual user or entrepreneur]. As far as mobile devices used to seek information in the internet are concerned, the respondents usually mentioned mobile phones (Fig. 4.5).

The respondents sought information in the internet with different frequency – half of them did that at least once a week, and the rest – less than once a week. The most often sought subjects include timetables (public transport in the city / trains / planes) – 25% of the respondents needed this kind of information at least twice
a week. Another useful kind of information was information about traffic jams, road works and other traffic obstacles – 33% of the respondents sought this kind of information at least once a week (Fig. 4.6).

Fig. 4.5. Devices used to search for information on the internet, in the respondents’ categories. Based on: [The quantitative…, 2011]

Fig. 4.6. Frequency of desired information. Based on: [The quantitative…, 2011]
From the respondents’ answers, the researchers could conclude that it was not difficult to find the desired information but the correctness of the description of a desired destination might vary significantly. The estimation of the time needed to reach a destination appeared to be the key element of the desired information. The remaining aspects are a bit less important (the route, distance, opening hours) (Fig. 4.7).

During a telephone interview the respondents were also asked about the most important features of information sought with the use of mobile devices. The most important appeared to be the up-to-datedness of information. Mobile devices are usually used in a situation of planning how to reach a given destination – on foot or by a means of transport. The conditions in which they are used require a certain “profile” of information available through a mobile device. Due to the nature of the information sought and the fact that it is necessary in a given moment – 2 attributes appear equally important: the speed and ease of access, and reliability and completeness of the information obtained (Fig 4.8). The ranking of the validity of information characteristics did not vary depending on the category of users. The up-to-datedness of information was definitely the most important. Juxtaposing the expected features of information with the ways in which mobile devices are used confirms the importance of up-to-datedness and reliability of information, as well as an easy and quick access to it.

Also, a situational context of using the internet in order to find information about how to reach a destination was studied. It appeared that seeking information on the internet takes place usually at home, in the respondents’ free time, during their professional activity or while studying (e.g. at the university, in a library). Using the internet while travelling (on longer or shorter distances) was declared less often, which shows that navigational applications are not yet that popular (Fig. 4.9).
The key conclusion in the opinion of the respondents concerning the features of information is that a mobile application should provide the most current data.

As far as the device to seek information is concerned, the respondents usually used a computer (see Fig. 4.5), but in order to develop mobile applications it was crucial to learn about the information sought by those from among the respondents.
who used mobile devices. The users of mobile devices who used them to seek information more often than once a month were students (27%), entrepreneurs (9%) and individual users (15%). The most desired information included: public transport timetables, train and plane timetables, and events in Poznań – all the sought information subjects are listed in Fig. 4.10.

![Fig. 4.10. Kinds of information searched for on the internet through mobile devices, in the respondents’ categories. Based on: [The quantitative...], 2011](image)

The most important conclusions summarizing the results of the quantitative research include:
- The respondents usually sought information concerning transport e.g.: timetables of means of transport, routes to given destinations, and concerning events taking place in Poznań. Apart from that, the desired information included also the topography of the city, retail and service outlets, e.g. food outlets.
- The estimation of the time needed to reach a destination appears to be the key element of this kind of information. The remaining aspects, such as the route, distance, opening hours, are a bit less important.
- Seeking information on how to get to a given point takes place usually at home but relatively often also at work or school.
- The internet is the key source of information. Notice boards and friends are much less frequently used as sources of information.

The respondents sought information in the internet with different frequency – half of them did that at least once a week, and the rest – less than once a week. The analysis of the results indicates that it is not difficult to find desired information.
- The most popular device used to seek information on the internet is still a computer. With this respect, mobile devices are used definitely less often – every third student and fewer than every fifth individual user or entrepreneur. Among
mobile devices used to seek information on the internet the respondents usually mentioned mobile phones.

- The users of mobile devices use them to seek information on the internet every day or almost every day. This is, basically, the same information as in the case of searching via other devices – information about how to get to a selected destination or about events in the city.
- The key element of information is its up-to-datedness. Due to the nature of the information sought and the fact that it is necessary in a given moment – 2 groups of attributes appear equally important: the speed and ease of access, and reliability and completeness of the information acquired.
- Less than a half of the respondents used a GPS device; those who did were usually entrepreneurs, more often men than women and people over 30 years old. This type of navigation is used significantly more often through a special device installed in a car than in the form of an application on a mobile phone.

The results of the qualitative and quantitative research confirmed to a large extent the assumptions concerning the expectations of users of mobile devices. They also confirmed the assumptions concerning the situations in which the application was used – when it was suddenly important to find such information and there was no other way to do that, i.e. no access to classical media – guides, maps.

### 4.4. Studies testing the mobile city application

In this subchapter we present the assumptions of tests, their preparation, the process of testing and conclusions are presented in chapter 7 entitled “Testing of the Mobile City application and the extent to which it meets the requirements” by Magdalena Graczyk.

Similarly as in the case of the research into the needs of users, testing of the trial version was conducted on a group of respondents whose structure corresponded to the target group of users. From the perspective of costs specification, three groups were distinguished, which included:

- students (about 25% of the testers), studying in different years, coming from out of Poznań, studying different fields of knowledge excluding computer science (due to their area of interest, knowledge and skills, the students of this field were not a representative group for this research, they could only be used as a comparative or expert group);
- individual users (about 55% of the testers), these were people under 45, living in Poznań or in the Poznań district – and entrepreneurs (about 20% of the testers), who recruited from people running their own businesses and employing workers, also freelancers or senior managers; the group was diverse with respect to sex and place of living (Poznań or the Poznań district).
Similarly as in the case of studies conducted before the application was designed, the testing of the application was also outsourced and conducted by a research company called Cogision Sp. z o.o. Unlike the opinion and expectation surveys, in the case of the testing of the ready solution it was important to use tools dedicated to the study of mobile technology. The application testing was conducted with the use of three research tools:

- moderated usability testing – an authoritative source of information about the degree of usability of interactive products,
- field usability testing with a think aloud protocol,
- diary research conducted in the form of an internet blog, aimed at recognizing strengths and weaknesses of the application.

The studied groups of respondents had to meet the following criteria:

- have some experience in using internet applications such as Google Maps, Zumi, and GPS navigation;
- have an own smartphone with access to the internet (including an active data packet), the Wi-Fi function (to connect to the wireless network during the test application in a testing room), a camera (for testing QR codes).

The tests were to answer the following questions:

1) as far as the evaluation of the ergonomics of the application’s interface is concerned:
   - how much time does it take to find a desired piece of information (time of the scenario implementation)?
   - how much time does it take to complete further steps related to information seeking (time of the completion of further steps of the scenario)?
   - how many steps must be completed in order to find the desired piece of information (the number of completed steps – transitions between screens – in the scenario implementation)?
   - is it easy to find desired orders/buttons/functions – the intuitiveness of the interface?
   - what is the perception of the size and arrangement of interface buttons – is it right?

2) as far as the evaluation of the interface is concerned:
   - the evaluation of the application with respect to information content (rated on a scale of 1–5, with reasons):
     - is the information up-to-date?
     - is the information complete/sufficient/sufficiently detailed?
     - is the information reliable?
     - what is the perception of the ease of the access to information?
   - what is the result of the evaluation of the speed of finding information, with respect to specific functionalities of the application (do they work and meet the user’s expectations - rated on a scale 0-1, with reasons):
− QR codes,
− geolocation,
− geocoding – determining the longitude and latitude on a map on the basis of the address of a place,
− routing,
− navigation along the route,
− providing detailed information about the destination.

All the aforementioned aspects important for the improvement of the designed application were the subjects of the analysis conducted in cooperation with the company. The detailed testing process and the conclusions from it are described in Chapter 4.

4.5. Research conduct management

It is very difficult to determine what kind of changes, which could affect the implementation of the plans, will take place in the organization and its micro and macro environment in the following more than ten months (or even fewer than ten months). The difficulty in predicting the future is related largely to the development of new technologies, especially new solutions in the field of teleinformation technologies. Designing, implementing, and – most importantly – commercializing of the solution requires predicting many factors which may affect the implementation of the project. The ability to collect data, determine the possible relationship between the data and analyze their impact on the market success of the proposed solution was the subject of the research conduct management.

The fundamental reasons for changes related to factors coming from the environment – market factors in particular – concern the actions improving the competitiveness of the offer. In the case of the Mobile City application, which is an open and publically accessible web application, keeping up with the expectations of the users was particularly important.

Determining the factors which could interfere with the planned actions is one of the fundamental tasks of the project management. Because management is based on information and decision-making processes which should be supported by the research process, all the activities in the project were preceded by acquiring information. The acquired information came from both secondary sources (which is described in section “Preliminary studies based on secondary sources”) and primary sources (“Research into information needs and expectations concerning the interface of a mobile device”).

The proposed application, as well as the entire project, were an R & D undertaking, had a unique character – very dynamic and yet very sensitive to environment factors.
The reasons for changes, their scope and significance are very varied and their sources can be found both in the external environment and internal factors, e.g. the team’s work.

During the research supporting the design of the system, special attention was drawn to external factors to influence the development of the application and – as a result – the implementation of the entire project. The typical external variables include:

- **Market factors** – maintaining an adequate level of sales requires developing the product range and keeping up with the needs of buyers. This forces producers of mobile applications to systematically improve their products. The activities of market entities related to strengthening their competitive position are a special subject of marketing research. It must be remembered that using navigation and providing desired information, as in the case of the Mobile City application, provides measurable benefits to the users – economic ones (route optimization) and those related to safety (support in driving) [Gotlib, 2011].

- **Changes in clients’ expectations** resulting from their rising needs and better awareness or the changing fashion must be taken into account and not only as they arise but even before – they should be anticipated to efficiently place a new offer among the competitive ones.

- **Legal conditions** – the changing standards of information transmission, regulations by virtue of acts, e.g. the law on the access to public information, patent applications protected by the law, local (municipal, local government) administrative rulings – are also important for the design of commonly available applications involving data sharing. Taking into account the legal requirements is also related to the accessibility and cost of the provided descriptions of urban space. The owner of this space is usually the state, whereas the description of urban space, e.g. cadastral data, topographic data, and geographic names may be the subject of trade [Gotlib, Iwaniak, Olszewski, 2007].

- **Scientific studies**, the development and dissemination of new technologies (requiring and/or allowing for the use of modifications) – translate directly into commercial activities on the market, but due to their wide range and diversity they should be analyzed separately in the research. In the case of the research related to the implementation of the project, its scope exceeded the area of academic studies and concerned also practical applications, also in the fields of logistics and transport [Longley et al., 2006] – hence, the research included also the analysis of the needs of entrepreneurs,

- **Socio-political factors** – e.g. international commercial contracts concerning trade, or protests of local groups against global solutions.

Among the issues affecting the implementation of the project there are also internal factors related to the work of the team implementing the project, or institutions in which the team operates. As in the case of the external factors, also in relation to internal factors we can distinguish certain categories:

- **Updating the project assumptions** – the changes in the implemented project in relation to the planned criteria – in the case of competition, multi-stage and de-
velopmental projects, it is absolutely essential that the assumptions are updated. Developmental projects, due to their specificity, must keep up with (or even be ahead of) the market needs; for this reason the implementation of the project had to take into account both the project assumptions and the changing conditions of the market.

- Acquiring new knowledge – in the process of the implementation of the project the project team acquired ever broader knowledge, both about particular technological and IT solutions and in the area or useful solutions encompassing IT, ergonomics and marketing at the same time. This aspect was especially important in the process of the research because the IT areas as well as issues related to geolocation are developing very dynamically and are characterized by significant variability [Narkiewicz, 2007].

- Iterative inclusion of changes – current and detailed testing of the proposed solution provides systematic guidance to introduce changes. The most fundamental changes are those related to accounting for new technological possibilities not taken into account in the project assumptions.

- Transitions in the organizational structure of the entity implementing the project – they may have a significant impact on the success of the undertaking. Macroeconomic phenomena may change strategies and assumptions of the organization, but in the case of short-term and small (in terms of the team and the budget) projects, such factors are of minor importance.

- The performance of outsourced tasks may also be a factor requiring monitoring due to its large impact on the project implementation. In the case of the outsourced tasks related to the Mobile City application, the project team prepared the whole of the assumptions of the research tasks, coordinated them regularly and as far as it was possible - took part in them. The rationale behind the performance of the outsourced tasks was the optimum use of tools, methodology and specialist and up-to-date knowledge in the field of the outsourced issues. This made it possible to reduce the costs of the project implementation, ensured better flexibility of introducing changes and updates, and enabled the project team to concentrate on planning, organizing and integrating actions within the project.

The implementation of the project and the research it involved confirmed the accuracy of the assumptions and the concept described in the project application, e.g. in the scope of the proper identification of tasks, estimation of the budget, selection of the team and specifying properly the range of possible modifications making it possible to flexibly fit the project into the changing technological environment.
5. Principles of ergonomic interface design of a system for mobile use of information in urban space

WALDEMAR PRUSSAK

5.1. Introduction

Using interactive mobile devices is nowadays a significant part of people’s everyday behavior. Therefore, the ergonomic quality (ergonomics) of systems providing information in mobile conditions is now the subject of many theoretical and practical studies. This quality means the extent to which certain requirements are met. These requirements concern the compatibility with human capabilities (physical, sensory, emotional and intellectual) and limitations through a set of properties determining the nature of the system.

The kinds of problems most often encountered by the users of mobile internet services are as follows [Budiu, Nielsen, 2011]:

- small screens,
- uncomfortable input, especially for typing,
- long loading time,
- Inappropriately designed websites (i.e. not meeting the requirements of easy access from mobile devices).

Following the principle of ergonomics in the whole cycle of designing interaction with systems providing information in mobile conditions makes it possible to improve the efficiency of use, decrease the probability of mistakes, increase security and satisfaction of users.

5.2. Basic concepts

The aim of ergonomics in relation to a system providing information in mobile conditions is enabling the user to perform a certain task in a certain context in a satisfactory way. The ergonomic methods and tools of such systems are developed in the areas of their creation, analysis and evaluation. In order to enable the evaluation of the system from the perspective of achieving the aforementioned goal, we need to distinguish criteria which are sufficiently independent and characterize important requirements concerning the user’s interface. The most fundamental set of
such criteria includes (see: [ISO 9241-11, 1998; Nielsen, 1993; Shackel, 1991; Shneiderman, 1998]):
- efficiency,
- effectiveness,
- simplicity (easy to learn),
- satisfaction.

The aforementioned criteria can be corresponded by specific requirements towards the dialogue between human and the system formulated in such a way that the user can plan and perform his or her tasks in certain conditions. These requirements take into account the user’s capabilities and psychical features, e.g. ability to concentrate, a limited short-term memory capacity, the degree of skill, etc.

The aforementioned criteria condition the actual state of interaction between the user and the mobile system, which prevents analyzing its quality from a one-sided perspective, omitting the use of a feature characterizing only the system itself. The aforementioned criteria are interrelated, e.g. the satisfaction of the user depends on the ease with which he learns to interact with the system.

The technological and ergonomical quality of the system ensures its usability. This is related to all the aspects of the computer system with which a man can cooperate [Nielsen, 1993]. It describes how well human can perform tasks with the use of this system [Newman, Lamming, 1995]. In literature there are many definitions of this concept. They point out different aspects of usability, among them:
- providing human with support in work,
- integrating the system with the environment in which it is used,
- enabling the user to perform tasks efficiently and effectively,
- specifying the context of use,
- ensuring the compatibility of the project with basic principles,
- providing support for learning.

Usability can characterize the quality of the system, assuming that conditions in which the system is used are specified. It is potential quality in these conditions. The system’s quality in use is defined as quality perceived by its user when he uses the system in a given environment and in a given context of use [ISO 9126-1, 2001]. It is the quality of the result, characterizing the system in a broad context of use – performing actual tasks in a real environment.

Designing a useful system providing information in mobile conditions is the main aim of the system’s designer. The knowledge about the future use of the system and the opportunity to actively participate in its design may make users significant participants to the process of design. This approach is a result of the user centered design (UCD) concept, the process in which needs, expectations and limita-

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1 More about different definitions of usability can be found for example in [Prussak, 1998; Sikorski, 2000].
5. Principles of ergonomic interface design

The basic principles of the UCD include paying attention to [Gould, Lewis, 1985; Preece et al, 1994]:
- focusing sufficiently early on users and their tasks, including ensuring that their physical and mental characteristics are understood and taken into account,
- measuring the properties of the system at all stages of design,
- an iterative approach.

The ISO 9241-210 [ISO 9241-210, 2010] standard includes human-oriented design as a multi-dimensional activity, taking into account the knowledge of ergonomics. This kind of design should be a constant process throughout the life cycle of the interactive human-computer system. The UCD includes planning the process, specifying the context of use and the users’ and the organization’s requirements, creating design solutions and evaluating them from the perspective of the user’s requirements.

The usability characterizes the interaction of the user and the system in a specific context from which the interface cannot be separated. The description of the context is essential because the interaction between the user and the system is placed in a given context of space and time.

A discipline called Computer-Human Interaction involves designing, evaluating and introducing interactive computer systems for people, as well as researching into most of the phenomena which accompany this process.2 (human-computer interaction – HCI). According to A. Dix, the HCI deals with research on people and computer technology, and ways of their mutual influence [Dix et al., 1998].

5.3. Ergonomic guidelines designing interfaces for the mobile use of information

General guidelines

On the basis of the general principles concerning the ergonomic aspects of designing the interaction between human and computer system (e.g. [Constantine, 1995; ISO 9241-110, 2006, 1996; Nielsen, 1994; Nielsen, 2005; Norman, 1988; Preece, 1993; Shneiderman, 1998; Tognazzini, 2001]) we can formulate general principles referring to a broader set of criteria for the ergonomics of systems providing information in mobile conditions [Prussak, 2008].

On the basis of these principles, a set of basic properties of a usable system providing information in mobile conditions can be composed. Such system should (see: [ISO 9241-12, 1998; Juristo and al., 2004]):

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2 This definition of this discipline was formulated by the Special Interest Group on Computer-Human Interaction of Association for Computing Machinery [ACM…., 1992].
be able to inform the user about what is happening throughout the whole time when the system is used;
be able to deal with errors – correct or prevent them;
be coherent – in all the aspects of the interaction, i.e. as far as the interface and functionality is concerned, able to present repeating information in the same way;
be able to provide assistance – rich in information, easy to use and appropriate, thanks to which the user will better understand how to handle the system;
be able to minimize mental stress – it should minimize it through, e.g. [Withrow, 2010]:
- using the feature of mobility (thanks to the geographical location of the user by the system and matching the displayed information to his position),
- satisfying the preferences and patterns of the user (thanks to the function of remembering the most often selected elements and the last actions),
- improving the performance of tasks;
be clearly controlled by the user – give the user a sense of controlling the interaction¹;
be naturally modeled – showing clear relation between what the user expects and the operation mechanism;
be easy to navigate – ensure the ease of moving within the system’s structure;
be accessible – it should not offer only limited access; this property includes also internationality, multi-channeling and accessibility for the disabled;
be clear – it should present information in a fast and precise way;
be distinctive – it should make it possible to clearly distinguish between actions and elements of the system;
be brief – presenting only as much information as it is necessary to perform a task;
be detecting – drawing the user’s attention to information he needs;
be readable – ensure the ease of information reading;
be understandable – making information more accessible for the user.

The aforementioned features may be achieved when following these general guidelines for designing systems providing information in mobile conditions:

- General Design Guidelines for Mobile Devices [Nikkanen, 2004]:
  - design for users to go,
  - enable fast use,
  - keep it simple,
  - provide feedback and navigation cues,
  - include self-recording capabilities – even if the network goes down, the system should not;
- general content design guidelines for mobile devices [Nikkanen, 2004]:
  - present the most important content first,
5. Principles of ergonomic interface design

- keep content compact,
- do not make the page layout complicated,
- use simple text elements and styles,
- pay attention to page titles (short titles, preferably less than 15 characters),
- keep documents small,
- use compact link names (one or two words),
- design clear forms,
- use smart graphics – it must be informative and simple;

- general navigation design guidelines for mobile devices [Nikkanen, 2004]:
  - minimize steps in navigation,
  - selecting instead of typing,
  - keep the navigation consistent throughout the service,
  - design flat menus – a deep hierarchy makes the use more difficult,
  - cross link – provide links to the starting page,
  - provide confirmations for important actions,
  - searching should be intuitive;

- 15 Guidelines for handheld mobile device interface design [Gong, Tarasewich, 2004]:
  - enable frequent users to use shortcuts,
  - offer informative feedback,
  - design dialogues to yield closure,
  - support internal locus of control3,
  - aiming at consistency,
  - allowing easy reversal of actions,
  - providing simple error handling,
  - reducing short-term memory load,
  - designing for multiple and dynamic contexts,
  - designing for small devices,
  - designing for limited and split attention,
  - designing for speed and recovery (a possibility to quickly save and later resume any work already performed in the system),
  - designing for “top-down” interaction,
  - allowing for personalization,
  - designing for enjoyment.

The usability of systems providing information in mobile conditions depends on many different factors and, following the aforementioned principles, it is diffi-

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3 It is about providing the user with a sense of control over the system. Interactions should be designed in such a way that the user feels that he controls the system and not the other way round.
It is difficult to satisfy all the needs of the user, whose opinion depends usually on the experience of using the system in a specified context (see: [Johnson, Nardi, 1996]). Nevertheless, when designing such systems, it is undoubtedly wise to take into account general principles and guidelines of functionality.

**Applying principles and ergonomic guidelines in a user-centered design of interfaces for the mobile use of information**

Because human’s working memory has a limited capacity, the quality of an interface is greater if it allows the user to focus on solving problems and not on the interface itself [Mayer, Moreno, 2003]. This is especially important in relation to users of systems providing information in mobile conditions who perform such tasks as, for example, observing their environment, and can be additionally distracted by changes taking place in this environment. Therefore, interfaces of mobile systems should help users to obtain information without (or almost without) them having to employ their memory and focus too much (visually) on the interface. Therefore, it is advisable [Adipat, Zhang, 2005]:

- to enable the control of the interaction with the use of mechanisms requiring less visual attention, such as input/output possibilities with the use of touch or voice [Gong, Tarasewich, 2004; Pham, Wong, 2004],
- to categorize information and present them in a hierarchical form which the user can penetrate when he needs more information [Qiu et al., 2004; Fang et al., 2004],
- to put more important information higher in hierarchy [Kärkkäinen, Laarni, 2002],
- to make it easier for the user to focus for some time on one specific part of the screen [Mayer, Moreno, 2003],
- to predict search possibilities in order to easier locate objects (e.g. functions or information) [Jones et al., 2002].

A system providing information in mobile conditions must be made accessible and usable also by people of limited abilities [Shneiderman, 2000].

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5. Principles of ergonomic interface design

Because the greatest advantage of a mobile system is the access to public information in different situations, more and more context-aware systems appear. The context-awareness is based on the information detected by environment sensors (e.g. the levels of temperature, light and noise), the location of the device, the possibility to connect with other devices and knowledge about the goals of users and their preferences [Häkkilä, Mäntyjärvi, 2006].

Taking into account the context of using the system providing information in mobile conditions, it is advisable:

- to provide the user with functions allowing him or her to switch the system on and off [Jameson, 2003],
- to inform users about the consequences of changes in the interface setting before they make them [Jameson, 2003; Stephanidis et al., 1998],
- to inform users about receiving context-specific information such as the intensity of environmental factors [Jameson, 2003],
- to provide context-specific information only when the user needs it [Barkhuus, Dey, 2003],
- to provide users with options enabling them to set the priorities for information [Barkhuus, Dey, 2003].

A significant ergonomic problem is the efficient presentation of a significant amount of information on a small screen of a mobile device. A good solution should allow the user to understand information and relations between the displayed contents [Spence, 2001].

A technology for presenting information which uses advanced graphic presentations to display data in a relevant and indigenous way is visualization [Spence, 2001; Ferster 2012]. Its three-dimensional taxonomy [Shneiderman, 1996] may be referred to systems providing information in mobile conditions [Adipat, Zhang, 2005]. Hence, it is advisable:

- in relation to one-dimensional content containing text documents:
  - enable to review the whole content in a hierarchical structure [Buyukkokten et al., 2002],
  - limit the depth of the hierarchical structure of the menu [Parush, Yuviler-Gavish, 2004],
  - place important content on the top levels of the hierarchy [Kärkkäinen, Laarni, 2002],
  - provide the user with the information about where he is in a given document (e.g. by means of a pop-up menu presenting the review of the whole content and indicating the present position / page) [Spence, 2001],
  - ensure clear and understandable messages [Parush, Yuviler-Gavish, 2004],

Context means here all the information which characterise situations related to the interaction between users, system and their environment [Dey et al., 2001].
- ensure clear marking of the text box in which changes must be made to correct data incorrectly entered into the form [Budiu, Nielsen, 2011],
- use brief and meaningful labels [Kärkkäinen, Laarni, 2002],
- ensure the shortest way to reach a given element [Jones et al., 1999],
- avoid horizontal scrolling (with the use of presentation optimizing techniques) [Jones et al., 1999],
- use buttons, layout and names in the menu coherently in the whole system [Gong, Tarasewich, 2004; Parush, Yuviler-Gavish, 2004],
- use pop-up menus or transparent widgets to save place on the screen [Kamba et al., 1996],
- use graphic content and text in moderation, limit the necessity to enter data / fill forms,
- limit the necessity to enter text (using suggestion and automatic completion as well as allowing for the use of abbreviations) [Budiu, Nielsen, 2011],
- limit the length of a line of text in the entry box (of a form or browser) to 30 characters [Budiu, Nielsen, 2011],
- provide the user with an easy way of removing default content [Budiu, Nielsen, 2011];

- in relation to the 2-dimentional content including pictures, maps and tables:
  - present images only if their content is meaningful (not for decorative purposes) [Budiu, Nielsen, 2011],
  - provide the user with a possibility to display the review of information [Spence, 2001],
  - place on the same page all the elements which constitute lists (if these are text elements or if they are ordered in accordance with the requirements of a given task) [Budiu, Nielsen, 2011],
  - if a list includes only one element, move the user directly to this element [Budiu, Nielsen, 2011],
  - provide the option of sorting if the elements in a list may be sorted in accordance with different criteria [Budiu, Nielsen, 2011],
  - provide filters if a list includes objects belonging to different categories [Budiu, Nielsen, 2011],
  - use a drop-down menu sparingly (its label should clearly indicate that it is a menu) [Budiu, Nielsen, 2011],
  - in order to make it possible to provide detailed information, use the two-level zoom or the fisheye view [Gutwin, Fedak, 2004],
  - in the case of maps, give directions (N, W, S, E); if the system uses data to locate the user from the GPS receiver, show the location of the user on the map and indicate towards which direction he or she faces [Rakkolainen, Vainio, 2001];
5. Principles of ergonomic interface design

- in relation to a 3-dimentional content including the virtual reality of the existing objects:
  - make it possible to see the whole object and scan it with the option of zooming in and out [Spence, 2001],
  - provide flexible navigation functions (up, down, forward, backward).

L. Chittaro [Chittaro, 2006] proposed that solutions concerning visualization of information in mobile devices should arise as answers to the following questions:

- in what way is visual information coded?
- which of the available information pieces are important for the performance of a given task?
- how are visualizations displayed on the available screen space?
- what measures are applied to ensure interactivity?
- have human perception and cognitive abilities been taken into account?
- have the efficiency of visualizations been tested on users?

In mobile systems it is advisable to use adaptive interfaces which dynamically configure the presentation of information on the basis of users’ actions. Such interfaces use additional information known as interesting for certain users and adapt the style and form of the presentation in accordance with a given user’s preferences [Savidis, Stephanidis, 2004; Stephanidis et al., 1998].

A good adaptive interface should be characterized by its controllability, predictability, comprehensibility and unobtrusiveness [Jameson, 2003]. Such features can be achieved through:

- getting the user’s consent before the adaptation of the interface [Jameson, 2003];
- explaining to the user the adaptive strategies and asking him or her for confirmation [Jameson, 2003];
- providing the user with the possibility to configure options [Stephanidis et al., 1998];
- using a cohesive layout, many names and informative feedback [Jameson, 2003];
- providing the mechanisms of input and output requiring minimum visual attention [Gong, Tarasewich, 2004];
- using a multimodal interface, based on the context change and an ability to adapt to disabled users [Stephanidis et al., 1998];
- enabling the user to use visual control when:
  - he or she has an acute sense of vision, especially in the case of the hearing impaired [Caldwell et al., 2004],
  - the information consists of an important image and graphic data which require visual attention;
- enabling the user to use hearing control when:
– he or she is busy with tasks which engage his or her hands (e.g. driving a car) [Gong, Tarasewich, 2004],
– he or she is in an environment which worsens his visual capabilities (e.g. in a dark room), especially if he or she is visually impaired or physically disabled [Caldwell et al., 2008],
– he or she is not in a noisy environment,
– the need for information is urgent and requires immediate response;
- enabling the user to use touch control when:
  – he or she is at a public event such as a concert or a meeting [Barkhuus, Dey, 2003],
  – he or she has to perform other manual activities [Pham, Wong, 2004],
  – he or she prefers privacy [Barkhuus, Dey, 2003].

Providing ergonomic input solutions in small mobile devices is difficult and requires a certain level of operational proficiency from the user [Zhang, 2003]. One solution is to use a software keyboard, which is an element of the software implemented with the use of a touch screen displaying the image of a keyboard. The dimensions, shape and layout of the software keyboard is regulated so that it can change depending on the screen of a given mobile device [MacKenzie, Soukoreff, 2002]. The use of a software keyboard requires the user to focus his attention on the screen. This solution may be used when the user can direct his eyes on a mobile screen which is sufficiently large to display a keyboard.

Other unimodal solutions include the use of technologies recognizing handwriting [Fang et al., 2004; MacKenzie, Soukoreff, 2002] or speech input [Oviatt, 2000]. A solution preferred by users and aimed at improving data introduction to mobile systems is the multimodal access [Lai, 2004].

The basic idea behind the HCI is direct manipulation [Hutchins et al., 1986]. According to B. Shneiderman, an interface in which direct manipulation is used is characterized by the following features [Shneiderman, 1998]:
- the continuous representation of objects of interests,
- simplicity (is easy to learn),
- it enables the user to physically operate with objects instead of using a complex structure,
- it provides fast, incremental, undoable actions, which have an immediate visual impact on the object itself.

The arrangement concerns static and dynamic elements of the interaction of the graphic interface (drivers and the so-called widgets). To support the operation there are: frames and meshes of the layout. Objects are arranged with the use of

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6 A set of elements (points, lines, shapes) limiting the layout of interaction objects.
7 A set of parallel horizontal and vertical lines dividing the screen into units of specified visual and notional integrity [Vanderdonckt, 2003].
many visual techniques, such as composition, association and dissociation, ordering, etc. [Vanderdonckt, 2003]. The formulation of guidelines concerning these techniques is often based on the results of ergonomics research.

Problems concerning the design of systems providing information in mobile conditions may be grouped in three main areas:

- the design as a whole (basing the interface on web browsers or basing the interface on the application),
- the use of the screen space (dependant on the size of the screen and the resolution, the orientation of the device, the intuitiveness of the approach to a given interaction – an index finger or a thumb),
- the mechanisms of interaction (gestures – tapping, sliding/slipping fingers, dragging).

As far as using the screen space is concerned, it is advisable:

- to place important elements higher and less important elements lower (while at the same time, it must be remembered that it is difficult to manipulate elements placed on the top of the screen),
- to group similar elements so that they are accessible without having to scroll the display screen,
- to reduce the number of displayed items to really necessary ones (this concerns both text and image content) and hide some objects using, e.g. the drop-down menu function,
- to create large interactive areas (the touch icon of the interface should be at least 10 mm tall and wide) [Budiu, Nielsen, 2011],
- to design interactive objects so that they look interactive (using the shape and color8),
- to place important buttons in the centre of the screen in the lower half of the screen (it is difficult to press buttons which are near the edges of the screen when manipulating the interface single-handedly),
- to place buttons and links in clear lines and columns (leaving enough space in between for touch control),
- to label groups of option buttons and checkboxes above them, indicating functions (as an exception, checkboxes and option buttons can be labeled on the right side of the box / button),
- to use standard icons (preferably icons with descriptive and precise labels)9,
- to try to limit the number of characters in lines of text to 55–60 (spaces included),

8 The rules concerning the choice of colours for a graphical user interface (GUI) are presented for example in [Wandmacher, 1993; Marcus 1995].
to use short, descriptive headlines and avoid abbreviations,
- to differentiate elements using strong contrast (which is especially important if the system is used in strong sunlight),
- to provide the user with the possibility to personalize settings (to zoom the interface, to change the colors and font).

In order to make efficient interaction possible it is advisable:
- to use simple navigation (menu must not take a lot of space and be visually clear in terms of the layout),
- to use physical buttons to control the device,
- to limit the necessity of text introduction (offering lists of options and predictive / suggesting functions),
- to always provide well visible buttons (there should be no functions controlled only with gestures),
- to make it possible to control all the functions with just one finger (it might be necessary to use buttons which become visible after a certain area of the screen is touched),
- to be consistent (e.g. to place buttons with particular functions in the same area of the display),
- to provide feedback and information on the state of the system (e.g. confirmations of the user’s actions, data loading, readiness for further operation after a while in which the device was not used, warning against the timeout),
- to avoid distinguishing objects with flickering (it should be used only in the case of urgent and critical messages [Sanders, McCormick, 1993]),
- to support the user in dealing with errors (clear information about errors and – if possible – suggested solutions),
- to provide shortcuts for regular users.

Detailed examples of good practice in the field of designing systems providing information in mobile conditions, including: navigation, searching, sorting and filtering, feedback, tools, forms, lists and tables, cards, invitations and aids are presented in [Budiu, Nielsen, 2011; Neil, 2012].

5.4. Conclusion

Research conducted by D.J. Gillan and his coworkers [Gillan et al., 1992] showed fundamental differences between the approach to the usability of products of specialists in ergonomics and computer scientists. Ergonomists clearly concentrated on users, whereas software designers focused on the computer system. Only user-oriented design can remove these differences in approach.

Concentrating on ensuring high usable quality of the interface of a mobile system may bring certain benefits, including (based on [Karat, 1994; Marcus, 2002]):
5. Principles of ergonomic interface design

- increased efficiency – a more usable interface makes it possible to the user to concentrate on the content, not the tools;
- increased productivity – a more usable interface takes less time to deal with;
- reduced number of mistakes / increase in safety – a more usable interface contributes to reducing the number of mistakes whose results may be dangerous for human and human environment;
- less training – a more usable interface is easier to learn and takes less training;
- reduced need for service support – a more usable interface creates fewer problems and requires less service support;
- increased acceptance – a more usable interface is more accepted and more willingly used,
- increased sales – a more usable interface may be a marketing asset.

Consistent taking ergonomic principles and guidelines into account while designing interfaces of systems providing information in mobile conditions efficiently promotes the achievement of these benefits.
6. Prototyping

MAGDALENA GRACZYK, FILIP KIERZEK

6.1. Introduction

The prototyping of GUI – Graphical User Interface – is often done in the early stage of designing a computer system. It involves the creation of a prototype software interface in a relatively fast and cheap way. The aim is to produce a model of the ready computer system in order to test its selected aspects from the perspective of its future users.

Prototyping is an important part of the iterative method of computer system development and it involves regular evaluation and testing of the designed solutions. Using unified methodology of user’s interface creation provides complete technological solutions and supports access to interactive applications and services though – among other things – dealing with the variety of requirements from end users, also disabled ones [Leonidis, 2012]. Prototyping itself also usually takes place in an iterative way. The developed prototype is tested and the results are taken into account in the process of developing new prototypes. The prototype (model), having reached the stage in which it meets the requirements, becomes a part of the computer software design. Once the prototype is accepted, the model can be implemented.

In the first part of this section stages of preliminary prototyping works are described. They must be completed even before the prototyping proper begins. Further in this article, prototyping types and methods are described, and the choice of methods for the project “The Integrated support system for access to information in urban space” is justified. (The project is hereinafter referred to as “Mobile City”). Then, technological limitations which significantly affected the development of the final version of the prototype are specified. The next part includes the presentation of sample paper designs and screenshots from the HTML5 prototype. Apart from that, sample scenarios of selected functionalities of the system are presented.

6.2. Before prototyping begins

Prototyping should take place in accordance with the techniques of interaction design targeted at users [Wiethoff, 2010]. In order to properly design a prototype we must properly describe the aim of the designed tool, taking into account the needs of the future users. There is relevant literature which offers information on good practice devoted to prototyping and interface creation [Gualtieri, 2009;
An important stage in prototyping is planning the functionality of the IT system. Basing on two tasks in the Mobile City project, the hierarchy of computer needs was specified and functional requirements from the system were determined. These activities took place during:

- Task 1: “Analyzing the needs of the system’s users in terms of information and operation; analyzing the validity of these needs” and
- Task 2: “Analyzing the possibilities of using the data included in the urban database (in cooperation with the employees of the Poznan City Office) and identifying limitations on the use of city data in the created system, as well as possibilities of minimizing these limitations”.

The functional requirements are described in the internal documents of the project as prototyped functionalities and then implemented in the IT system.

Before starting the prototyping works and choosing the method of visualization of interfaces, conclusions from the research on information needs in urban space were thoroughly analyzed. As part of the hierarchy of information needs developed during Task 1 and 2 in the Mobile City project, 20 consecutive and most important information needs were distinguished (in a descending hierarchy): public transport, location on maps, weather forecast, private transport and timetables, traffic congestion, routing, pharmacies on duty, emergency, opening hours, location of shops, tourist facilities, services, restaurants, pubs and cafes, sports and sports clubs, offices – location and opening hours, events, entertainment, the job market, the history of Poznan, promotions and prices. This analysis was the basis for the creation of a list of the system functionalities described in detail in the documents of the system; among them: data structure (including the description of point and non-point data), synchronizing data with the data sources of the City of Poznan, collecting data from the server, displaying the main application screen, displaying the results in a list, presenting the results on a map, sorting results in a list, displaying details about an object, filtering search results based on attributes, searching by name, mapping operations – display, zoom, moving, the user’s own points, notifying about needs, notifying about events, showing driving / walking routes to objects, positioning on a map for a given address, showing departure time at the next public transport (MPK) stop, standard operations for each location, processing of QR codes and downloading related information, identifying users / user profiles. The described functionalities were prototyped by the design team in accordance with the interface prototyping method described further in this study.

At present, there are several kinds and methods of prototyping, among them:

- **Paper prototypes** – (printed, drawn) or made of magnets are created fast and make group work possible, they are usually imprecise and little literal. Their advantage is that no technological knowledge is required from designers, which allows to engage in the work on the prototype a more diverse group of people. There are two ways in which to continue works on such paper prototype: first of them is the presentation of the prototype to a wider group of those interested in
the final product; the other way involves starting the system with the use of a set of existing models or hand sketching of the prototype [Medero, 2007; Giensburg, 2011; Solly, 2011]. Design with the use of paper prototypes consists of several steps [Bolchini, 2009]:

- The creation of a paper prototype – this can be done basing on the already existing practices. The number of prototypes should be equal to the number of screens presenting main and key task scenarios,
- The digitalization of the paper screen – taking a photo of such quality which will later allow to “cut out” the window and adjust it to the size of the screen. Another digitalizing method is scanning and importing to edit image.
- The change of the size of the photograph – adjusting the size of the photograph to the screen of the mobile on which the first version of the prototype is tested. Scaling can be done using commercially available software to resize images.
- The export of the changed file to the format supported by the mobile device (e.g. PNG, JPG, GIF). The ideal image should meet the device screen at the meeting point of the prototype outline in the photo format.
- The organizing of photographs – involves sorting photographs in folders and setting them in an order to make it possible to present the sequence of shots and tasks corresponding to the test scenario.
- Copying the photograph folder on a mobile device and validating the display of the prototype windows.
- Testing the prototype involving scrolling on a mobile phone screen consecutive windows of the test scenario cycle. At this level of testing, every user has the right to openly express his opinion on the interface and the sequence of screens.

- **Concept prototypes** – designed basing on the content and function and not the arrangement on the page. Concept prototyping makes it possible to focus on the content and not the graphics. The disadvantage is omitting the question of the interface itself and ergonomic solutions in the graphic design of the prototype, which may ultimately lead to errors in the logical communication of the prototype. The concept model itself does not mention the source code and solutions are presented in a way similar to natural language [Rychlich, 2008].

- **Visual, static prototypes** are very similar to paper ones but they are prepared as graphic files; they constitute strict guidelines for the graphic designer preparing the system layout. The introduction of changes in such prototypes is very complicated. At the same time, not every member of the design team can in an easy and fast way introduce amendments into the prototype, which – ultimately – makes it necessary to engage people fluent in graphics programs, i.e., in fact, the less numerous group of the project team.
**HTML / Visual Basic / SuperCard prototypes** (or other tools making it possible to quickly prototype in an electronic form) first of all require from the team (or at least one of the persons in the team) proficiency in using the tool in which the system is designed. Prototyping using this method makes it possible to make ongoing changes and test the functionality of the prototype. Each new button can be added on a regular basis without having to create every time the whole new solution. The purpose of this method is to check the proper operation of the logical system, not the graphic elements of the created solution [Klee, 2000].

More and more research is now conducted in the field of the prototyping of systems for mobile devices. In order to better understand the user, it is necessary to conduct the proper evaluation of the prototype and to test it before the implementation.

Paper prototyping was chosen for the Mobile City project, supported by prototyping proper in HTML5 technology. The reasons for these choices were as follows: In paper prototyping every member of the project team could participate, even a non-specialist in computer science. This approach allowed for a broader perspective which included computer science, marketing, ergonomics and quality. As a result – a better prototype could be developed. Having developed the paper prototype the project team checked whether it met all the possible and planned scenarios of usage.
If the answer was positive, the HTML5 prototype was developed and tested with respect to the scenarios of usage. In another task of the project, the initial version of the IT system was tested by the future users of the web application. Having analyzed the results of the tests, the project team introduced changes and improvements. The testing of the prototype by users is described in Chapter 8 of the present monograph.

6.3. Technological limitations

While designing the GUI and making the prototypes, the project team had to take into account the limitations related to the mobile project technology used in the project. The adopted technology was HTML5. The choice was the result of many factors. The first of them was the high uncertainty as to the future development of mobile platforms. When the project team started the project, it was difficult to predict which platform or platforms would dominate the market. Also, the budget of the project did not allow to create the applications in many versions - form many different mobile platforms. For the purpose of the project, the project team had to choose one technology for the construction of the application. The choice of HTML5 was related to the fact that it allowed to run the web application on any platform equipped with a web browser, which significantly reduced the risk that the chosen technology may no longer be popular at the end of the project. Apart from that, HTML5 is a new technology, the use of which would involve a number of risks in the case of a commercial project, whereas in the case of an R&D project like this one, the fact that it is a new and relatively immature technology was no obstacle to use it to construct an IT device.

The creation of an IT device basing on the customer-server technology and HTML5 imposes certain limitations in comparison to the creation of a native application for a concrete mobile platform. The most important of these limitations are the following:

- lower productivity of the application,
- differences as far as the supported functionalities of HTML5 on different platforms and browsers are concerned,
- the lack of access or limited / difficult access to many of the native functionalities of the platform, such as a compass, gyroscope, camera,
- difficult distribution of the application
- no authorization during installation, difficulties in data processing by mobile devices,
- difficulties in performing some more complicated operations locally, e.g. advanced search – the need to operate in the client-server mode.

The speed of the web application depends on three factors: the speed of operations on the server, data transmission speed and the speed of the user interface on a mobile device. From the perspective of design, the interface drawing efficiency in
an application appeared to be a significant factor limiting the design capabilities of our application. The use of jQuery Mobile library caused significant problems with the speed of the whole application in the case of a large number of elements of the user’s interface or a need to upload a large amount of data. Nevertheless, ultimately this is unlikely to constitute a significant limiting factor. First of all, mobile browsers continue to develop and among the available browsers there are such which can successfully handle a complicated JavaScript code in an efficient way. Additionally, the libraries supporting the creation of mobile applications such as jQuery continue to be optimized which translates into their speed. Moreover, the efficiency of mobile devices themselves grows. Devices equipped with dual-core processors are more and more popular and quad-core processors (containing four cores) are also entering the market. In accordance with the Moor’s Law [Moor, 1865] we can expect that within 2 or 3 years the efficiency will no longer be a limitation for the use of this technology to create advanced mobile applications.

The support for HTML5 technologies in mobile browsers while designing was usually significantly limited and varied. HTML5 gradually becomes more and more common but even today (September 2012) the support for it is not complete. Moreover, there are still numerous differences in the interpretation of the specifications by different browsers, due to which some of the designed screens looked differently on different platforms. This problem can be illustrated by problems with “gluing” the top bar of the application to the top of the screen, so that only the part displaying the list of results could be scrolled. Some browsers, instead of keeping the top bar of the application constantly in place adopted another solution in which this element scrolls with the page and then returns to its place when the scrolling is over.

Another problem involves the placement of buttons related to the use of the map which tended to “stick out” of the screen in the Safari browser (iPhone’s platform).

Another significant disadvantage and problem was the issue of obtaining permission to locate the user. Different browsers have different ways of obtaining the user’s consent to disclose his location to the application. Some display a notification on the top of the screen, others - at the bottom, and some - in the form of a modal dialogue box. These differences result in frequent situations when users ignore or unconsciously reject the application’s request for access to their location (which was revealed by the usability tests). This happened many times when the project team tested the first version of the application. An additional problem was the fact that in the case of most browsers, withdrawing the lack of consent for the location of the user required significantly more effort than giving consent for it. In most cases, withdrawing the lack of consent involved looking for deeply hidden configuration options, which was beyond the willingness and ability of most users. With this respect, the application model in which the application displays commands asking for further authorization (e.g., sharing your location) before the installation seems to be more understandable to the user. Such solution causes also fewer problems and leads to greater satisfaction while using the application.
The lack of access to native functions limited the scope of possible functionalities of the web application. The lack of access to the compass made it impossible to include the functionality involving indicating directions. The use of the method in which the direction is deduced from the changes in location requires the user to be in motion. The car navigation functionality, i.e. informing the user that he should turn left/right, etc. was theoretically possible in the form of a JavaScript application, but time and budgetary limitations of the project made it impossible to carry out such works under this project.

6.4. Prototyping in the Mobile City

A good illustration of the process of prototyping in the Mobile City project is the process of creating a prototype on the basis of the Filtering Screen. A filtering screen is used to limit the number and kind of objects on the list of results or the map of results in accordance with the criteria provided by the user. It is therefore necessary to present the user with such criteria according to which filtering may take place and with possible values of these criteria to choose from, so that it can become the basis for the filtering process.

The first stage in the paper prototyping phase was the creation of a set of symbols to mark different elements of the user’s interface. Such symbols perform a function similar to that of the symbols used on maps: rivers are marked blue,
main roads – red, historic buildings with the use of certain icons, etc. Such symbols must have a key, i.e. a list of symbols used on given diagrams together with explanations. The symbols for paper prototypes in the Mobile City are as follows like Figure 6.2.

Additional symbols exceeding the set presented above were explained by an additional key presented on the screen under design.

The Filtering Screen presented in Figure 6.2 was made on the basis of the following fragments of the specification of expectations:

3.4.6. Sorting results in the list
The Mobile Application is to provide the following ways of results sorting:
- acc. to the distance from the user (his current or selected position)
- acc. to the final rating (in the maximum area of X km from the user’s position); the value X (the distance) should be possible to select in an easy way from the screen of results
- acc. to the weights taking into account the final rating and the distance from the user’s position
- alphabetically.

3.4.8. Filtering the list of results according to attributes
The user is to be able to interactively filter the results of his search in order to shortlist them to objects which respond to his interests. Hence, the Mobile Application is to make it possible to filter the search results in the list in accordance to the selected attributes defined for a given category.

The filtering of the list may take place for attributes of the following types:
- bool – a yes/no attribute
- enum – choosing one value from a finite list of values
- opening hours – in order to filter the currently open objects
- rating – in order to show objects of minimum rating not lower than the provided one
- rating – in order to show objects which have desired products of any rating

Moreover, filtering can also take place according to the distance from the user’s position or from any other selected location on the map.

The above points specify filtering and sorting of the results. Filtering is to take place on the basis of attributes (criteria) which may be of various types. An example of the criterion “object accessible to persons with disabilities” has the so-called logical type of possible values “yes” and “no”. Criterion “cuisine type” is of the so-called “list” type, i.e. it is possible to choose from a finite list of possibilities. A functional goal which the project team attempted to achieve was the creation of a screen which would be able to dynamically fit different attributes existing for different categories in a given system.

On the basis of the requirements presented above, a series of paper prototypes was created. The first of them was the paper prototype presented on the work meetings of the project team (Fig. 6.3).
This prototype included filtering according to logical attributes (true/false) and selecting from the list for the filtering of attributes. Confirm/cancel buttons were placed on the bottom of the screen. Additionally, there were labels which further specified the functions of individual parts and a small key which clarified the meaning of some symbols of the elements used on this page. The full key was placed at the beginning of the document including all the paper models. Each of the prototypes was also given a short description intended to clarify the operation of a given screen. For example, for the aforementioned prototype, the description looks as follows:

*It makes it possible to give values for filters available in a given category. The view of this screen depends on the filters actually available for a given category.*

*Some elements of this screen will repeat regardless of the kind of the displayed objects:*
- object rating filter – only objects rated higher than X
- object distance filter – the distance of an object from the current position of the user

*The screen operates in a select and close mode. This means that after the user has selected the value of the attribute according to which the results are to be filtered, the screen closes and shows filtered results. If the user wants to filter according to more than one attribute, he opens the screen again and selects another attribute. The assumption is that the user will want to filter according to more than one attribute only infrequently, so it is worth to close the window after the filter has been selected.*

*Moreover, the screen is to enable the user to change the way of sorting of the results in the list (not shown on the previous screen). This is to take place through selecting sorting options from the list of sorting options. Sorting options are to be available as the first ones in the list.*
Each paper prototype, after it has been redrawn to the final version, was included in the document “Mobile system project”, which - by means of the Google Docs system – was shared by all the members of the project team. At the weekly meetings of the team, new prototypes were discussed and results were included in new iterations of the prototyping. For example, the above prototype was then redeveloped to the following form like Figure 6.4.

Fig. 6.4. Filtering Screen version 2 – an example of the paper prototype in the Mobile City project

Sometimes drawn models were also used (in order to maintain the proper proportions) directly on the scheme of the example target device in 1:1 scale.

Fig. 6.5. An example of the paper prototype in the Mobile City project – a drawing on an example mobile device
The collected prototypes (models) of screens from a given functionality area (in this case – from the area of “displaying results in the list”) were implemented, which gradually led to the creation of the HTML prototype. The HTML prototype had the final user’s interface but did not make it possible to actually perform any real operations of results filtering. Only after conducting the tests on a given part of the functionality, which positively verified the assumptions concerning its operation, this part of the functionality was fully implemented and became a starting point to prepare a ready IT device.

The combination of screens constituting the HTML prototypes with the already implemented (operating) screens made it possible to make the next step in the verification of the prototype – the analysis of the so-called test scenarios. Figure 6.7 presents one of them, which concerned the process of searching for information.

The members of the team, using the prototype of the application, tested particular ways of going through the application. This allowed to eliminate logical errors and inconsistencies hindering navigation between particular screens.

The last stage of prototyping of the user’s interface of the application involved the so-called usability tests. They indicated the areas where end users of the application had problems understanding the function of any of the elements of the application or where a problem manifested itself in a significant amount of time needed to complete a given task. The methodology of the usability research was described in detail in the next chapter – Chapter 8.
Fig. 6.7. An example of a test scenario from the prototyping stage in the Mobile City project
7. Testing of the application and meeting the requirements

MAGDALENA GRACZYK

7.1. Introduction

The tests of the tool in the project “The Integrated support system for access to information in urban space” were aimed at determining the degree to which the key requirements from the IT tool (the Mobile City application) are met. Tests conducted at several stages, on a group of 20 users, made it possible to evaluate the functionality of the tool usage. The tests analyzed and evaluated: the ergonomics of the application’s interface, the information content, particular functionalities, graphics, the application in general. The result of the tests relating to the scope of the feasibility, ergonomics and usability is the internal document “List of Modifications” created by the project team in order to improve the web application and the whole system.

The first part of this chapter is devoted to the methodology of testing of the Mobile City application. Further, the results of the consecutive stages of testing are described, together with recommendations of changes. The last part is the description of the degree to which the application meets the requirements of the system’s users, a summary of this section of the chapter and an indication concerning the direction of further works.

7.2. Analysing the usable quality of the software – theoretical issues

The most important aim of testing the usable quality of the software is the identification of errors which make it impossible to use the software. Such errors may concern both ergonomics and technology, and they may make the proper operation of the device impossible.

Testing may be conducted with the use of many commonly known methods [Mazurek-Łopucińska, 2005] e.g.: surveys, panel studies, qualitative methods of collecting information and research using the measurement of qualitative variables (e.g. attitude research). Descriptions of research into the usable quality of software can be found in literature [Fitzpatrick, 1999; Nielsen, 1990; Prussak, 1998; Shneiderman, 1998]; they include: [Prussak, 2006]:


inspection methods – without users, used primarily to detect potential problems concerning the usability through expert testing of the user’s interface with the use of a set of instructions or questions; inspection methods include: maintenance controls, cognitive walkthroughs, heuristic methods, modeling.

Methods with users – usually involve people from the outside of the project team; these methods include: observations, interviews, questionnaires, group research and empirical research.

The most interesting from the aforementioned methods are:

- Product overview – a method involving verifying the compliance of the interface with standard guidelines (e.g. ISO) [Dzida, 2000], the consistency inspection [Wixon, 1994] makes it possible to control any selected sites / applications from a selected family and verify the consistency of names, colors, layout, input and output formats.

- Cognitive walkthrough [Prussak, 2006; Lewis, 1994] – involves imagining the walk through the interface of a user who needs to accomplish a task for the first time and foreseeing problems which the user may come across while using the interface.

- Heuristic evaluation [Prussak, 2006; Molich, 1990] – involves expert, critical review of the interface in order to determine the compliance with the list of design heuristics; this method requires the participation of experts but they are not required to justify their assessment.

### 7.3. Testing methodology

In the project, the proper testing was conducted in 3 states on a group of 20 respondents, using the method with the participation of users. Persons taking part in the research came from various target groups selected according to quota-random sampling. The representatives of the groups were chosen depending on their:

- place of living: inhabitants of Poznań (permanent or temporary) or people from outside of Poznań,
- profession: 10% entrepreneurs, 50% students of different universities,
- age: 60% adults up to 45,
- sex: 50% women and 50% men.

Additional skills of testers taken into account in the recruitment process were:

- advance smartphone using skills – 50% testers; the advanced level of smartphone use means here:
  - using the internet on a smartphone at least once a week,
  - having experience in using internet applications such as: Google Maps, Zumi and GPS navigation,
  - having experience in using different internet browsers,
  - familiarity with and acceptance of internet novelties;
7. Testing of the application and meeting the requirements

- non-advanced smartphone using skills – 50% testers (people not meeting the criteria of advanced users).

After each stage of the testing, modifications of the web application were introduced in order to minimize the number of recurring errors. As a result, each new stage of testing allowed to descend on a lower and lower level of detail and capture more errors in utility, ergonomics or workmanship\(^1\). Time intervals allowed also to introduce modifications and improve the testing methodology, and at the same time – to increase the benefits from each new round of testing.

The researchers applied the think aloud protocol, which enabled them to obtain additional information regarding the feelings and opinions of the respondents.

The testing included:
- usability tests in a laboratory,
- usability tests in the field (in Poznań),
- diary studies,
- and they were conducted in compliance with the schedule presented in Fig. 7.1.

\[\text{Laboratory tests} \quad \text{Diary} \quad \text{Field research} \quad \text{Diary II} \quad \text{Laboratory tests II} \quad \text{Implementing the recommendation}\]

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Fig. 7.1. The schedule of conducting tests on the Mobile City application

During thirty minutes of independent work with the web application, the participants, supervised by a moderator, tested several scenarios of using the application on smartphones. Research sessions were recorded with the use of the Morae software, dedicated to observation and behavioral analysis during the usability tests of the web application (Fig. 7.2).

Laboratory tests were conducted on a group of 6 people in a specially prepared room. During the test, in the laboratory there was one tester and one moderator. Respondents used a smartphone with the Android system. In the total time of application testing in a laboratory, three testers – one by one – had to complete an in-

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\(^1\) The users sometimes found the same problems, due to which the benefits from testing were less and less significant with every user taking part in the tests.
individual user test which consisted of 11 tasks. The tasks imitated the way in which the application could be used in different everyday situations.

Field studies were conducted in a group of 2 people in Poznań. The observations of the field studies were recorded in the form of notes of the person conducting the study and surveys filled by testers after completing subsequent tasks of the test. The research concerned in particular the following fields:
- the navigation, the browser and the results of browsing,
- the process of showing routes leading to a selected point (by car, public transport or on foot),
- the content and the way of presenting the results.

The diary studies were conducted in a group of 12 people. Every day during the testing period, the users of the Mobile City application had to post an entry on a blog. Before the testing, the testers were given a list of issues which they should concentrate on while doing the tasks. During the analysis of results of the diary studies the researchers concentrated first of all on the following fields:
- the context of use,
- the types of desired information,
- the process of searching for information,
- the quality of desired information.

Each of the tests ended with an interview with the respondents. The interviews together decided about the results of the final report from the testing.

An additional study conducted on a group of 50 people at the Poznań University of Technology as part of the internet and mobile marketing classes; the students were asked to:
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- evaluate the data basing on their own criteria of information features, e.g. the amount of details, accuracy [Goliński, 2012], which met the standards expected from the information of the Mobile City application;
- introduce test data by 20 students in a management panel of the Mobile City application; the data were introduced in accordance with the user’s own judgement concerning their information needs;
- 11 respondents were asked to test the data in the Mobile City application introduced into the management panel;
- to analyze the compliance of the information attributes sought by students with the features of data introduced into the management panel;
- to correct the test data in accordance with the suggested testing results.

The testing, apart from the identification of functional and technical errors in the administrative panel allowed also to evaluate the quality of information published in the Mobile City application.

7.4. Testing results

The tasks related to testing the Mobile City application were aimed predominantly at finding functional errors and strengths and weaknesses of the application. It was taken into account that active users of mobile applications have already some experience in using the existing and available partial solutions of the tested application. It was very probable that respondents were used to the existing solutions and would compare them with the tested web application.

The results of the testing were presented as consistent results of each of the 3 consecutive stages of the Mobile City application testing. The tests were not conducted on the representative group of people and the results of this research may not be treated as statistically significant.

Stage I

In the first stage, during the first round of the laboratory testing, several categories of problem areas were identified.

The first of them was navigation (enabling the user to get to a desired place). The respondents had no problems understanding the operation of this function. The main problems concerned technical errors including: not working, unlit or too small buttons, no graphic distinction of full functionalities or overlapping buttons.

The browser is one of the most important functionalities in the Mobile City application. Problems indicated in this area included first of all: the limited number
of data, the search algorithm incomprehensible to the testers, misinterpreted scope of search, unintuitive search with the use of a map.

In the case of the routing functionality, users – used to Google map solutions or the Polish application jakdojade.pl – encountered a number of problems during the task solving. Having understood the principle of routing in the application, they still had problems changing the automatic GPS location. The most important problems diagnosed by the respondents in this area included: problems with setting a starting point, no clear information about the current starting point, no searching for options “from … to”.

The way of presenting content, including the detailed description of POI should provide the user with desired information. The respondents had problems understanding some functionalities, e.g.: listing of the search results, the names of labels and icons. The respondents pointed out that they found messages on errors in GPS location annoying, just as the lack of messages on the changes made.

After the problem areas were diagnosed the following recommendations were suggested:

- improving the visibility of full names of own tabs on the widest possible range of devices with different resolutions,
- changing the logic of the division into categories: assigning all the services to one parent category, joining or changing the logic of the division into “free time”, “culture” and “events”,
- emphasizing visually the fact that the application operates in Poznań,
- concentrating particularly on data concerning the city of Poznan,
- arranging all buttons in such a way that they do not cover other fields displayed as search results (Fig. 7.3),
- increasing the intuitiveness of the manually set GPS location,
- extending the base by: all the POIs in the city of Poznań, film screening lists or public transport timetables,
- extending the proposed route to a given place using public transport by giving an alternative route, marking points of change clearly and presenting the on-foot route in a clear way,
- enlarging the buttons to zoom in and out the map,
- using understandable symbols of particular functionalities e.g. public transport symbol (Fig. 7.3),
- unifying, proper formulating and displaying of messages for selected filters,
- extending the filtering by new positions: price, payment options, opening hours.

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2 The default search algorithm of the application gave results correctly only in the case of a large number of data in the repository of the application files.
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Fig. 7.3. Sample screenshots from the Mobile City application made during the first stage of testing

Recommendations which did not require time-consuming changes were introduced right after completing this stage of testing. Due to the fact that the data in the system are obtained from various sources (see the concept in Chapter 8), the project team was not able to significantly interfere with their edition, an additional group of test data was introduced “by hand”. The group of additionally introduced data was to complete and facilitate the testing of the application in further stages of testing.

Stage II

The second stage of testing is the 1st round of the diary and field studies. During the diary studies, attention was drawn to four main categories of problem areas: the context of use, the types of desired information, the process of information seeking and the quality of desired information. The testing made it possible to better understand the context of use of the designed application. The respondents claimed that using the web application is difficult and starting the application from the browser – inconvenient. The most frequent comments of the respondents included for example: no filters in the culture tab and an unclear division of categories.

The respondents appreciated the possibilities of filtering and sorting the results. In the case of field research, the testers had no problems understanding the navigation method. They especially appreciated the possibility to quickly return to

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3 Apart from the panel where data can be complemented with new criteria, by assumption, it is a properly working functionality for all the downloaded data of the same category.
the main screen of the mobile application. Most of the comments concerned technical issues. After the changes recommended in the first stage were introduced, the number of comments became visibly smaller. Critical comments concerned usually three issues: the fact that the filtering bar covered the navigation bar, problems by location, small buttons to zoom in and out the map.

The respondents had no significant problems testing the routing functionality leading to a selected point. In some cases, the respondents tried to get to a particular street, but the application proved unsatisfactory with this respect. The content and method of presenting the results of search not always met the respondents’ expectations. In the second stage of the usability and ergonomics testing the following recommendations were proposed:

- changing the method of the application’s operation – from a web application to a native application installed on smartphones,
- making the graphics of the application more attractive and modern,
- removing from the “transport” tag those points which do not give the users any important transport information,
- increasing the quality of point descriptions and complementing them by such information as the opening hours of shops and the times of events,
- expanding the database by cinema screening times and theatre repertory,
- extending the databases by a “night out” group with information on pubs or musical clubs,
- extending the database in the “shopping” tag,
- limiting the available places to Poznań and its nearest environment,
- adding filters in the “culture” tab,
- the clear division of data in particular categories,
- regular updating of the database and paying attention to the quality of the published data.

During the field studies more changes were suggested:

- arranging labels on the main screen in such a way that the full names of all the categories may be displayed,
- changing the icon of a bus into an icon of a taxi in the “transport” tab (Fig. 7.4),
- placing at the main page the name of the city or a symbol associated with Poznań,
- placing the navigation bar always on top,
- changing in the default settings and the way of saving location in the “GPS settings” box,
- improving the algorithm of route display and introducing a possibility to display an alternative route,
- adding information on the number of currently used filters,
- indicating the following on the map: changing points, stops and places where the user needs to change his way of travelling,
- more detailed consideration of the topography of the city for pedestrian routes,
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- increasing the buttons changing the size of the map,
- changing the public communication icon for a more intuitive one,
- changing the “remove filters” label when it is possible to use just one filter,
- placing information on the dates of events or opening hours in as many positions in the application as possible,
- limiting points in the database to Poznań and surrounding area,
- improving the operation of the browser,
- complementing the filtering functionality by all categories on the main page,
- correcting erroneous contact and address data of POIs.

Fig. 7.4. Sample screenshots from the Mobile City application made during the second stage of testing

Stage III

During second stage of the diary studies among the most important and frequent appearing problems identified by testers while using the application were: problems with setting an automatic location, problems with loading maps, or no possibility to download a native form of the application.

The testers emphasized that the high quality of the published content is the precondition for using this application in the future. Little attractive places should not be displayed at the beginning of the search results list. The testers pointed out several key problem areas: showing places remote from Poznań, no filters in the “culture” tab, unattractive graphics, ambiguous “transport” tab.

During the second round of the testing in the laboratory, the users encountered fewer problem areas concerning navigation. The most problematic area and
a source of numerous errors was the screen used to change the GPS settings. The most important problems indicated by the testers were: too small search boxes, a redundant button to remove a word entered into the search box, too little space between the map and the edge of the screen while changing the location settings.

The testers very often used the search box when trying to find the selected point. They used this functionality much more frequent than the tabs on the main page. The reported errors concerned: search results, no predictive function when typing in a phrase in the browser, the necessity to give the name of the street during the search.

The testers had the fewest problems with routing. Due to the fact that the users were used to searching for routes from A to B in other solutions, they needed some time before they learned the way of searching for routes in the application under testing. One person said that the operation of the browser after entering the name of the street in unintuitive.

The testers mentioned also the problem of names of events which fell beyond the screen.

In the last round of the testing, more changes in the application were proposed:
- leaving just one icon symbolizing a magnifying glass and removing the functionality of quick phrase deleting,
- adding example information about the kind of information to be entered into the search box,
- reducing the size of the map in the GPS settings box,
- adding information on the number of ratings (Fig. 7.5),

Fig. 7.5. Sample screenshots from the Mobile City application made during the third stage of testing
7. Testing of the application and meeting the requirements

- removing past events from the application database,
- adding the information of the closing time of events,
- adding the predictive function active when the name of a place entered is in the database (Fig. 7.5),
- reducing the number of tabs concerning free time,
- introducing separate symbols for both “my points” and “favorite points”.

Testing of the application conducted by students

Additional research conducted during the classes at the Poznań University of Technology in Poland concerned the usability of the Mobile City. The task preceding the study involved entering test data prepared by the students to the administrative panel of the Mobile City. These data were to be developed in compliance with the features of data searched for in urban space. If the users of the Mobile City receive data of the expected quality and the interface is ergonomic and friendly, than it is probable that the residents of cities of high population density will want to use the Mobile City application. In a questionnaire to evaluate the Mobile City application the following issues were analyzed and evaluated:

- the appearance of the website;
- the quality of the content;
- navigating through the website.

The survey took into account also the importance of data describing particular objects and the description of the scope of data requiring further work. The testers were also asked to express their opinion on necessary modifications and improvements, as well as the chances for development and improvement of the web application. The test was conducted in November 2012 on 11 respondents aged 25–50. From this group, 82% of people came from Poznań or the surrounding areas, the rest were newcomers or people temporarily residing in Poznań.

The appearance of the page was on average assessed as 3.5 on the 1–5 scale where 1 means the worst and 5 the best evaluation. The best evaluated criteria included: content layout and clarity, font size and readability of the main menu. The worst evaluated feature was graphics (eventually changed, as a result of the research) and the way of presenting data in various browsers.

Due to the fact that the aim of the project was, among other, improving the quality of access to information, an important category evaluated during the survey was the website content. The results of the evaluation of this category were good. The respondents emphasized the usability of the information included in the website as well as its up-to-datedness.

Navigating through the website was evaluated 3 and 4 on average. The best average notes were given to the functionality and the easy way of returning to the main page, the ease of navigating through the website and the time in which the page is loaded. Most of the data concerning the objects in the Mobile City system did not require any significant changes. The data include: precise location of the
object and presenting it on the map, information on how to get to the object, contact data, the link to the object’s internet website, opening hours, prices, description of the object and opinions. However, the respondents noticed that it would be good to consider changes in the following areas: the description of thematically similar objects, a possibility to share the link with friends and information on promotions.

All the respondents were of the opinion that the application is likely to develop and they would definitely use it very often (45%) or sometimes (55%). Using the Mobile City application the respondents were able to find information quickly (45%) or with an average speed (55%), which is promising and if the categories are improved and developed than there are significant chances for the commercialization of the solution.

7.5. Degree of compliance with design requirements

The respondents emphasized the fact that as of today, the limitations in the internet access do not allow to use this application easily and smoothly. They pointed out the significant time needed for loading subsequent pages of the application and the need to start an internet browser, which – together with problems with internet connection – negatively affected the quality of the application.

The respondents paid a lot of attention to the quality of data. They emphasized that the application will only be used if the data are reliable and detailed. What the respondents found important was the way of obtaining search results and aids used to “save time”, such as the predictive function.

Interesting information about the application was provided by the results of the “card sorting” study. The participants in the diary study were asked to solve a short test designed with the use of the Usabilitytools.com tool. The authors of the study took advantage of the tool used to test the Microsoft products. Microsoft Reaction Card is a tool making it possible to test the emotional reaction to the ready product.

The aim of the study was to see what kind of emotions this application arouses among users. Due to the fact that there were only 11 respondents of the study, the collected qualitative data may not be regarded as representative. From the list of 118 words available in the Microsoft method, the authors of the study decided to choose 30 cards so that the number of positive and negative expressions was the same. Each tester was asked to describe the product using as many words from the 30 available as desired.

The respondents had to accomplish the task on their own computers. The message sent to the testers included a link redirecting to the Usabilitytools. On the main website the tester saw a short instruction and a button starting the study (Fig. 7.6).

The tester started the task by clicking on the button. The respondent assigned cards taking them from the left side of the screen and moving to the right area on the right side of the screen.
7. Testing of the application and meeting the requirements

The cards chosen by more than 25% of the participants were as follows: easy to operate (55%), bad quality (55%), intuitive (45%), discouraging (36%), versatile (27%), slow (27%), freezes (27%), easy to use (27%), unattractive (27%).

It must be emphasized that the testers were often unable to separate the functionality of the web application from the quality of data which it included. The approach of the respondents and their opinion that an application is useful only when it can provide you with the information you are searching for made it impossible to obtain real and reliable notes concerning the operation of the application itself.

7.6. Conclusion

Testing of the designed application made it possible to gather many useful comments and suggestions of changes to be introduced in the final version of the
project. The project team itself would not be able to achieve such good final results and would not have corrected numerous visual, logical or qualitative errors.

What is worth emphasizing and was actually stressed by the research participants is that without good quality data it is impossible to fully implement this solution. A wide range of detailed information is necessary. Many detailed information and a possibility to efficiently and effectively filter the search results enables users to easily and quickly find a given object or event.

Each of the consecutive stages of testing brought new and more detailed conclusions. On this basis, a list of recommendations was made to implement in the project. After the tests were completed, selected groups of data were complemented with detailed descriptions. In this project, due to time and financial limitations, not all the changes were implemented; the recommended but not implemented changes are listed in a separate document which in the future will make it possible to further improve the product.
8. Description of the IT subsystem in the Mobile City application

TOMASZ SKAWIŃSKI

8.1. Introduction

The software of the IT subsystem has been created in the client-server architecture. The main goal of the development of the IT subsystem was to provide a logically coherent access to information coming from different, heterogeneous database sources, while maintaining the quality of the processed information. The use of the client-server architecture made it possible for the users of the system to explore large volumes of information regardless of the technological parameters of devices used to communicate with the IT subsystem. The structure and principle of operation of the subsystem is presented in the diagram below.

Fig. 8.1 The structure and principle of operation of the IT subsystem
Ensuring the level of access to information in urban space indicated in research required the integration of standardizing mechanisms through the application of: standardization, reduplication, validation and adaptive coding. The complexity of the aforementioned mechanisms had an impact on the decision to implement and use algorithms ensuring the quality of information on the part of the server. The transfer of the burden related to information processing on the server made it possible to “relieve” the client’s device, which resulted in increased productivity of the software running on the client’s device. An additional advantage was reducing the volume of data sent between the mobile device of the user and the server hosting the system, which in turn contributed to the extension of the working time of the device of the user of the subsystem.

8.2. Hardware solutions

From the hardware perspective, the IT subsystem consists of the server part connected to users’ devices such as mobiles, smartphones, tablets, laptops via the internet. The server part of the IT subsystem cooperates with the database software which serves as a repository of all information – both information shared with end users and systemic information which are essential for the proper operation of the subsystem. In order to manage information included in the repository we use the management panel constructed in the WWW technology. It makes it possible not only to review and modify the data stored in the system but also to manage the work of the whole subsystem.

8.3. Programming the server part of the subsystem

The proper operation of the IT subsystem is possible thanks to the software which coordinates services performed on the server. The role of the software working on the server is to aggregate information from various sources and then – to process, standardize and store them in the database, in a way enabling the users of the system to quickly explore the data, in accordance with the criteria of the formulated requests.

The control of the coordinating software takes place through the management panel. It was created in the ASP and .NET technology. The language used for the communication between the panel and the database is SQL. The database is a set of records grouped in tables including information which are in the scope of interest of the user and such which are used to manage the system itself. For this reason, the database is protected against unauthorized access. The scope of information stored in the database, apart from such elements as: the name of the object, information on the kind of business activity, the list of services and products offered by the object – includes also information necessary to locate the object on the map,
8. Description of the it subsystem in the Mobile City application such as: the address, the GPS coordinates of the location and the nearest public transportation stops.

The application for handling of users’ queries to the database is a WWW application to be downloaded to a mobile device from the WWW server. This application is an interface of data exchange between the database and the users. The WWW website offers users a convenient way to: add new objects of interest to the database, edit the existing entrances, update information included in the database; it also provides support for the transfer of data available in the form of digital data sets (e.g. from companies’ own databases).

Part of the server’s application is software supporting the queries of end users. It is also an intermediary in the communication with the WWW website. Based on the content of queries introduced by the user of the software running on the user’s mobile device, the server’s software searches the database, selects information which meets the criteria and lists them in accordance with the basic criteria in which the scope of value is defined by the user, acc. to the importance, price or distance. Finally, the application formulates a short set of answers which it sends to the mobile device.

Moreover, the architecture of the software working on the server’s page makes it possible to use a public interface of the API type to obtain additional information from private businesses and institutions as well as information on services publically available through the internet such as: browsers and price comparison sites, GPS maps, timetables, etc. Thanks to this solution, it is possible to expand the set of information available to end users while at the same time keeping the information up-to-date and maintaining clarity due to the lack of duplication.

8.4. Software running on the client’s part - mobile application

The role of the client’s software was limited to generating the interface, ensuring the interaction with the user, collecting and sending telemetry data coming from peripherals built in into a mobile device, such as: GPS, accelerometer and gyroscope. Moreover, as far as the communication with the server is concerned, the client’s software is responsible for the exploration of results sent as a response to the client’s query.

The software running on the client’s side was developed with the use of internet technologies. These technologies, through interpreted languages, provide a sufficient level of abstraction to use a web browser as a platform, independently from the degree of fragmentation of the market of operating systems. The dynamic increase in the use of mobile devices equipped with an internet browser allowed to develop software for a potential target group of unmatched number. According to the estimates of Internetworldstat, in 2012 the total number of internet users in the
world was 2.267 billion\(^1\). Moreover, the results of the research conducted by the Gartner company indicate that within the group of internet users the number of people using mobile devices is growing rapidly. According to their estimates, in 2013, the number of mobile device users should reach 1.82 billion\(^2\).

The use of internet technologies to develop the client’s application made the process of implementation easier because it made it possible to keep a coherent code, while maintaining backward compatibility. Moreover, it made it possible to reach the users of many platforms regardless of their operating system providers, while keeping the costs at the level of the costs of creating an application dedicated to only one platform.

An important aspect of the development of the software based on internet technologies is also the possibility to radically simplify and shorten the upgrade cycle. The process of providing new versions of software takes place without any action on the part of the subsystem’s user. The use of a simple channel to distribute software in the online mode provides the user with access to the latest version of the application, regardless of the scope and frequency of changes.

Moreover, there are HTML 5 extensions, now entering the stage of standardization (they include: Geolocation API, DeviceOrientation API, WebRTC API), which make it possible to communicate with such peripheral hardware components as accelerator, gyroscope, GPS, camera, barometer. The aforementioned extensions increase the capabilities of the applications developed in new internet technologies, run both on mobile devices and traditional PCs. The differences between functional capabilities of native applications assigned to a specific hardware platform and web applications become more and more insignificant, which is an additional argument for the latter.

### 8.5. Construction of the mobile application module

The Mobile Application is an element of the system used by an end user to satisfy his needs related to information in urban space. The name “Mobile Application” does not imply the implementation in the form of a code assigned to a single platform. Within the Specification of Requirements, the Mobile Application is understood as the whole of the system components providing this functionality without indicating the place where the code of the Mobile Application is executed.

The Application may run on both mobile devices and traditional PCs if only they are equipped with an internet browser. The software running on the client’s device was optimized in such a way that it can work fluently even on less advanced hardware configurations.

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\(^1\) [http://www.internetworldstats.com/stats.htm](http://www.internetworldstats.com/stats.htm)

\(^2\) [http://www.gartner.com/it/page.jsp?id=1278413](http://www.gartner.com/it/page.jsp?id=1278413)
The Mobile Application connects to the server in order to obtain data necessary to respond to the user’s query. The data are transmitted with the use of the techniques which make it possible to minimize the volume of the transmitted data, e.g. through compression or buffering. The mobile Application has an independent database which is a repository to store copies of the server’s responses. If the user’s query has already been answered and the answer in the database of the application, the application can use the repository to answer it without having to contact the server. The mobile application works in an “incremental” way, i.e. it immediately shows the user the search results and waits for additional criteria to filter the results.

8.6. Communication mechanism of the software running on the client’s part of the mobile application

It formulates the numerical version of a query adding to it information on the current location of the user coming from the GPS receiver installed in the mobile device or on the basis of the triangulation of the GPS signal. The generated query is sent to the server’s software. The server, having processed the query, sends back a filtered short set of data meeting the query’s criteria. Then, the user chooses one or more answers from the received set of answers in order to find out more about them. Once the choice is made, it is possible to locate the objects which are interesting for the user on the map and to learn how to get to these objects.

Queries concerning an object of interest may concern for example: the commercial offer related to the object (services or products), activity, opening hours, location on the map, directions, prices etc. For technological reasons and due to budgetary limitations the authors of the project – through the conducted research – selected functional areas of the system which are practicable and meet the expectations of potential users.

8.7. Mobile application functionality

The basic function of the mobile application is to present information searched for by the user. This information may be presented in the form of a list of results, points on the map or a detailed view of a selected object. Moreover, the application has additional functionalities increasing the user’s effectiveness with regards to operations directly related to searching for an object.

User identification

The Mobile Application can identify users when they log in into the server through a unique number further referred to as the id number; it is generated pseudo-randomly when the user first runs the application on a given device. The id number is recorded on the device and used whenever the application on a given de-
vice is started to communicate with the server. All the user’s data and the application’s settings are sent and stored on the server.

The user can register any time by giving his email address and password. The email address is confirmed by sending the user an email message with a unique and difficult to guess confirmation code.

Registered users can log in into the application using their email address and password. When the user logs in all his data are restored and the current settings of the application are overwritten.

**Locating on the map**

The Mobile Application is capable of showing the location of a given address on the map. This functionality involves entering by the user the address (street, house number, city) on the basis of which the application shows the location on the map.

If the entered name is ambiguous the system shows all the results on the map and lets the user select and display only those in which he is interested. The system makes it possible to perform all the standard operations for the selected locations.

**Operations for the object of interest**

For each place selected by the user the following standard operations are available:

- saving the place as the user’s point,
- pedestrian, public transport and car navigation to the destination,
- additional information about the place,
- searching for other places in the vicinity which also meet the search criteria.

**Displaying information on means of public transport**

This application shows the timetables of all the means of public transport departing from the nearest stops/stations.

Once the application is started, it shows a list of public transport stops together with the information on the directions, sorted according to distances from the position of the user or the position indicated by the user. It is also possible to see the stops on the map centered, by default, on the current position of the user. Moreover, if the stop is selected from the list or map, the application displays the relevant timetable.

**Route planning**

The application is able to navigate users travelling on foot, by means of public transport or by car from their current position to the selected destination. The scope of the function includes:

- showing the route on the map,
- giving the distance and the approximate time of travel on foot, by means of public transport or by car,
• if the user’s chooses the public transport option, the application displays the location of ticket machines and other places when tickets can be bought,
• recalculating of the route if necessary, e.g. if the user detoured off the proposed route.

Event notification

The application is capable of informing the user about events which correspond to his scope of interests and are in the vicinity.

The scope of the function includes:
• a possibility to subscribe to a selected group of events from among a detailed type and scope of notifications from a given category;
• mentioning at least the following events from the proposed groups:
  − road congestion,
  − public transport difficulties,
  − cultural events,
  − price promotions;
• a possibility to give more parameters to list and filter the number of notifications; the filtering parameters may be used in various configurations; it is possible to narrow the received notifications in accordance to subsequent filters:
  − the publishing date of a given piece of information,
  − the time of receiving the notification in relation to the time of the event,
  − searching through the notifications on events in relation to an area marked on a map,
  − in the case of the public transport – also in relation to means of transport (buses or trams),
  − in the case of events also in relation to the kind of event,
  − in the case of price promotions also in relation to the kind of promotion;
• a possibility to notify on events related to the change of the user’s location and the occurrence of an event in the vicinity of the new location, including notifications with the following options:
  − notify me when I pass by,
  − notify me when I am within a specific radius; the user is to be able to select the radius in relation to his present location within which he wants to be notified on events,
  − notify me always when I am in a given area; the area can be selected on a map by the user,
  − notify me when a new event is added.

Notification on needs

The application is also equipped with a functionality to save queries about the position of POIs which have not been found for the coordinates defined in the que-
ry. A query to indicate the nearest POI which does not exist for a given location may indicate a deficit whose scale is directly proportional to the number of negative responses to search requests in a given location. Correlating requests without responses acc. to criteria available in the mechanism of searching for objects may generate information on unsatisfied needs of users in a given location. Failures to find POIs are the results of search according to key words belonging to a selected category, which did not meet the user’s expectations. Each of the users has a possibility to use the aforementioned functionality and search for unfound POI positions in a given time and on a selected part of the map. On the map we can find all the results searched for according to key words of all the users which did not meet the expectations of the users of the application.

**Registering the statistics of application usage**

The Mobile Application is capable of registering all the actions of its users for research purposes. The collected data are anonymously transferred to the server for analysis. The registered actions are sent and stored in conformity with the user's privacy by connecting a randomly generated session ID. Information on actions taking place in the application may be stored in the browser’s cache and sent periodically, when the Internet connection is available. Basing on the collected data, it is possible to identify critical actions resulting in faulty operation of the software and to eliminate them. It is also possible to indicate the lacks in the functionality or a set of information made available through the subsystem.

**Defining own points**

This functionality of the subsystem enables the user to add his or her own location points. This makes it easier for users of the subsystem to explore preferred geolocation resources and makes the process of search and all the actions related to locations more efficient. Own points are related to the user’s account and available after logging in using the user’s login and password; they are not shared with other users of the system. The user is able to introduce changes in the set of preferred points by reading, updating and deleting them. The user can also mark one of the selected preferred points with a label conventionally called “home”, setting at the same time a quick selection shortcut.

**Processing of QR codes**

The application makes it possible to generate QR codes on the screen in order to provide another user – also the owner of a mobile device – with information included in the QR code. It is also possible to decode the QR code through making a photo of it and then conducting a digital analysis in order to read the data inscribed in the QR code. If there is a webpage address among the decoded data than it is possible to automatically go to this website. The application also enables users to
copy the selected pieces of information included in a QR code to a clipboard in order to use them at any time later. An advantage of using QR codes is the possibility to provide information in a standardized, universal way, independent from the hardware platform of the client’s device and telecommunication infrastructure.

**Adaptive rendering of the interface**

The implementation of the interface was executed in a way ensuring consistent functional access irrespective of the user’s hardware and the web browser. The interface has been designed in such a way that it guarantees clarity and ergonomics thanks to interactive elements displayed on the touch screen, such as buttons and form boxes. As a result, the layout, proportions and shapes of the graphic elements of the interface are tailored to the individual device categories differentiated by size and screen resolution. The interactive elements of the interface which are designed for touch handling are scaled so that they are consistent with ergonomics of the user’s hand. In order to increase the precision of tailoring the interface of the subsystem’s application to the technological capabilities of users’ devices, the devices were divided into three groups, each of which is characterized by the following parameters of the display:

- resolution up to 320×480 pixels or density from 240 PPI,
- resolution up to 640×480 pixels or density from 170 to 240 PPI,
- resolution up to 1024×600 pixels or density under 170 PPI.

The division of the users’ devices into the aforementioned groups makes it possible to better use the physical space of screens irrespective of their size and resolution. Limiting the number of supported versions of the interface made the process of development and maintenance of the software more efficient, and it increased the predictability of the interactions between the application of the IT subsystem and its users. Moreover, the application of an author’s solution of tracking the interaction between the user and devices which he uses while using the application of the subsystem allows for a high degree of personalization of the interface settings. The scope of personalization of the interface may depend on individual preferences and needs of users and modifications may be introduced gradually along with the depending of the knowledge on the subsystem’s application’s capabilities and along with the increase in the efficiency of the interaction.

**The structure of data and scope of information in the IT subsystem**

In order to make the exploration of information easier for the users of the system, its creators have decided to divide the information available in the IT subsystem into categories indicated by the research into potential preferences of the system’s users. The list of major categories was limited to nine, so that the graphic links to these categories may be placed on the main screen. Each of the categories may have various attributes assigned specifically to a given category, describing
objects belonging to it. Attributes are inherited from the supercategory to the sub-
category. The data in the system are assigned to one or more categories creating
a tee structure. A given category may have none or one supercategories and none or
many subcategories. Moreover, complex types of data may be used in the system.
Complex types of data are such data which are made of simple types of data (com-
ponents). They are used to represent information whose scope exceeds the storage
capacity of a single simple type datum.

The scope of information possible to use in a query was specified during the
implementation of the project on the basis of the analysis of users’ needs. This
analysis made it possible to determine which of the pieces of information on the
objects of interest are possible to obtain with the use of a subsystem of access to
information constructed in such a way.

Due to the presence of unique and repeatable geolocation data in the system,
two basic types of data were distinguished:

- Point data – correspond to objects in the city space, e.g. cinemas, cash ma-
  chines, restaurants, offices, shops,
- Non-point data – used to represent data which are not objects in the city space,
  e.g. a film screening, a theater premiere, other events, information about traffic
  congestion.

**Pro-quality mechanisms in the processing and distribution
of information**

In order to ensure the quality of the distribution of data available in the IT sub-
system, a number of mechanisms were introduced having impact on the most im-
portant features of information from the perspective of potential users of the sys-
tem, such as: completeness, up-to-datedness and precision.

**Rating mechanism**

The rating mechanism is related to objects with assigned location. The system
makes it possible to collect ratings assigned to POI objects by users and to use the-
se ratings when recommending POI objects to other users. Ratings express the ex-
tent of satisfaction of a user in relation to a given object. The user may rate an ob-
ject in the scale of five. Moreover, each user can write a short review – up to 1000
characters.

The mechanism managing users’ ratings makes it possible to:

- display summary ratings on the lists of objects, e.g. searched for, for a given
each category,
- sort objects according to the final rating,
- inform users about the final rating through displaying the ratings given by users
on the screen next to a given object.
All the collected ratings are stored in the system so that they can be used in future research as well as be recalculated if the algorithm for calculating the final rating changes.

**Mapping services mechanism**

The IT subsystem includes an implementation which makes it possible to use mapping services of various suppliers interchangeably. Such solution gives the possibility of changing the supplier with minimum effort related to adaptation. It is possible to flexibly extend the functional scope of the mapping services to better suit the developing system and changing needs of its users. It is also possible to gradually migrate from services of commercial suppliers to free services based on Creative Commons licenses, as the latter develop. Also services of many suppliers can be used at the same time – depending on the required scope and level of their services. The flexibility of mapping service integration increases the innovative potential through the ability to shape new services, based on cooperation with suppliers of information related by a base of common objects in space.

**Data optimization mechanism**

In order to optimize the amount of data sent between services performed on the part of the server and the application running on the client’s mobile device, a number of optimization techniques have been applied. One of the basic techniques used to reduce the amount of downloaded data is caching of the results of queries and static content. Moreover, managing the downloading records makes it possible to go to once visited webpages without having to load them again. Support for the offline mode mechanism increases the resistance of an application running on the client’s mobile device for errors resulting from poor quality of wireless signal. The scope of application of the offline mode is, however, limited to devices with a web browser with an appropriate support. Along with the development of standardization among the suppliers of internet software the scope of the use of the offline mode will be growing. As a result, it will be possible to start and use the application and the loaded recorded data also in the conditions when no internet connection between the client’s mobile device and the server’s services is possible. Data compression algorithms make it possible to send larger packets of data in response to the same query, while maintaining acceptable server response time. Limiting the number of queries between the user’s device and the server’s services contributes to reducing the load of the transmitting equipment, which in turn increases the energy efficiency of the device used by the user of the IT subsystem. The mechanism of data transfer optimization made it possible to increase the responsiveness of the application, which translates directly to its usability. The transmitted data volume management made the IT system more resistant to the fluctuations of the quality of internet connection provided by the operators of wireless telecommunication infrastructure. Transfer minimization is also an efficient way of reducing the
costs of using the subsystem for clients using wireless data transmission through roaming. The rational management of downloaded data decreases the load of server’s services and consequently increases the efficiency, which translates to a greater number of clients which may be served at the same time.

**Data import and update mechanism**

Data import and update mechanism involves periodically connecting the APIs of the project’s partners in order to download and update stored data. The system allows for integration with any entity having an access interface operating in accordance with the generally accepted standards of rational API construction using the XML and JSON formats, and communication standards such as: REST, HTTP.

The parametrization of the update mechanism includes the possibility to modify the synchronization settings in the following areas:
- synchronization frequency,
- type and quantity of synchronized data,
- mapping the representation of data from outer sources to the inner representation of the server, e.g.
  - categories e.g. restaurants – catering,
  - attributes, e.g. “type of cuisine” for catering, or “network” for cash machines, to the corresponding attributes of the subsystem.

**Database administration mechanism**

This mechanism makes it possible to manage categories and the structure of collected data through:
- creating the structure (hierarchy) of categories and subcategories for data in the system,
- defining attributes for various categories of data.

As far as managing categories is concerned it is possible to:
- add new categories,
- remove the existing categories and subcategories,
- remove the data ascribed to a given category and subcategory,
- edit categories – the name, description, the assigned icon, etc.,
- review all attributes assigned to a given category, both those assigned directly and those related by assigning to a super category,
- mark a given category as unavailable in the Mobile Application.

As far as managing attributes is concerned the system makes it possible to:
- review the list of attributes defined in the system along with the information on categories to which they are related,
- add a new attribute,
- remove the existing attribute together with all instances of its occurrence,
8. Description of the it subsystem in the Mobile City application

- change the name of an attribute,
- create the connections between an attribute and one or more categories.

**Data duplication mechanism**

Duplication makes it possible to remove redundant copies, i.e. data duplicates, automatically from the system, with the possibility of manual correction. The same mechanism supports also the functionality allowing to find:
- point data representing the same place,
- non-point data representing the same event.

Using hash algorithms in the duplication instead of traditional byte-by-byte comparison ensures the proper speed of the whole process, without compromising the infallibility. Moreover, global compression breaks data into blocks, which streamlines the comparison process.

**Mechanism to manage data usage statistics**

The mechanism of managing statistics includes generating reports whose analysis allows to continuously adjust the scope of data collected in the subsystem to the changing preferences of users. The generated statistics illustrate:
- the types of desired information,
- the frequency of searching for this information,
- the most often used functions of the application,
- assessment of the extent to which the information needs of users have been met,
- the functional scope of the IT subsystem, which causes the most problems in operation,
- the extent to which the subsystem was used by users in a given time interval,
- the average time needed to obtain a desired piece of information,
- the frequency of errors stemming from the incorrect operation of the IT subsystem.

**8.8. Conclusion**

The creation of the IT subsystem and the verification of its compliance with the expectations of the user (through conducting tests) confirmed the correctness of its operation and the validity of the assumptions made at the design stage.

The use of client-server architecture and the logic of the processing and distribution of information by the server proved justified in the face of significant discrepancies in the processing capability between the server hardware and the mobile hardware. The analysis of prototype solutions operating without the support from the server showed that, though possible, they are little effective due to the significant complexity of the mechanism of information integration and therefore - they would overload the hardware resources of mobile devices.
The utility research proved that applications created in internet technologies are skeptically received by users. This may be related to the lack of knowledge on profits coming from the use of internet application and from little technological maturity. The form of internet applications is perceived as unconventional and is often confused with a static WWW site. The popularization of the family of standards expanding the internet technologies’ capabilities, such as the HTML5 and the knowledge on benefits from the use of them will probably lead to the increase in the awareness and – as a result – to their more significant presence.

The creation of the software for the interaction with the user in the form of an internet application showed that – in spite of the great popularity of native applications – the area of applicability of internet technologies exists and will probably grow along with the development of new standards. The growing share of mobile devices in internet consumption as well as natural limitations of the wireless communication technology will stimulate the creators of websites to rationalize even more the data distribution channels and depart from the concept of composing Web sites on the server, turning to mobile devices. This tendency may also, ultimately, lead to blurring the differences between the concept of the website and internet application, and technologies used in internet applications may gradually migrate to websites; as a result – ultimately, every website using technologies from the HTML5 family may receive functional identity equal to that of an application. Such hybrid may lead to the popularization of mobile applications or give a new meaning to websites, making them a technologically neutral alternative to native applications.

The implementation of test scenarios in pseudo-real conditions and the received feedback confirmed also the validity of using the mechanism of data buffering and generating the interface on the part of the mobile device (due to numerous problems with access to wireless network). Moreover, the regularly conducted integrity verification tests made it possible to verify the correctness of the cooperation of each element of the IT subsystem and at the same time confirmed the reliability of the formula of the integrated system as a whole.

The most important was the verification of the system’s resistance to errors stemming from the occurrence of unusual situations, threatening the quality of services. Difficulties in ensuring the quality of the provided services stemmed usually from the limited access to resources of wireless telecommunication networks, as well as from difficulties in acquiring geolocation information. The efficiency of the response mechanism, confirmed by tests, proved that it is the critical element of the subsystem and its development should be treated as a priority in the case of possible commercialization. The ability to ensure the continuous operation of the subsystem irrespective of conditions and limitations is of the utmost importance to the efficiency of the applied technology and the error handling mechanism. The incorrectly performed interaction between the system’s user may efficiently limit the access to information resources, can destroy the effects of investments into guaranteeing the quality of information meeting the expectations of users. Efficient and
infallible operation of the response tool by detecting and eliminating errors is crucial from the perspective of satisfying the needs of users. The properly operating mechanism of error handling is the foundation of the usability of the whole integrated system.

The created subsystem proved its efficiency in real applications, satisfying the identified needs of urban space users. The module architecture of the subsystem, future-oriented software technologies as well as the flexibility of the data structure provide opportunities for the development and adaptation to the changing requirements of the market of information services.
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9.1. Information sharing and reusing in the light of the EU and domestic regulations

Intensive development of information technologies over the last years has taken place also in the public administration. Due to gigantic data resources and first of all due to their referential nature, broadly understood administration is more and more often becoming not only a desired partner but even an indisposposable participant in multi-party business processes. The economy cannot work properly and citizens cannot make right decision without quick and reliable access to reliable data and information from different public administration units. The significance of this fact, the meaning of access to basic data for the economy but also for citizens, who need this access to make everyday decisions, is reflected in legal acts introduced into both EU and Polish legislation.


The first of these directives specifies the free access to information resources and data resources of public administration units, while ensuring the possibility of re-using them by any entities, which should significantly increase the competitiveness and number of services.

The second directive establishes a common infrastructure of spatial information and the thematic groups of spatial data which have to be published in the

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\(^1\) The Official Journal of the European Union. O.J. L 345/90 of 31/12/2003.
form compliant with the model of data imposed in the provisions implementing the directives. The data have to be described with the use of metadata and must obligatory be made accessible through services referred to in the Directive.

In the Polish implementation of the re-use directive, which entered into force on 29 December 2011 as an amendment to the law on access to public information (which – together with the regulation on the Public Information Bulletinine [BIP] – is the fundamental document to regulate access to public information in Poland), the new rules of re-use of public information are described. Since that day there are new rules in force in Poland to regulate the issues of reusing public information and new limitations in access to information. Also, the form of the judiciary control in the cases when access to public information is denied has changed.

In the key part of the amended law, the rules of the re-use of public information are described. The obliged entities which give access to public information then re-used with the use of tele-information systems are obliged to use the data format and communication and encryption protocols allowing for machine reading, as specified in the regulations issued on the basis of Article 18(1) of the Act of 17 February 2005 on the computerization of the activities of entities performing public tasks. It is a very important provision as it forces public administration units, or – in a broader sense – all entities covered by the Act, to use technologies allowing to automate the collection and processing of information. Another important part of this regulation is Article 23b 1 which specifies conditions for re-using public information. This article reads that (apart from specific restrictions) public information is made available for re-using without any limitations and free of charge. This is of crucial importance in the case of undertakings and projects similar to the web application Mobile City developed as part of the project “Integrated system supporting access to information in urban space”.

Naturally, in compliance with the re-use directive in the Polish implementation it is assumed that the obliged entity may specify the conditions for the re-use of public information. These may concern:

- the obligation to disclose the source, production time and the time of obtaining of the public information from the obliged entity,
- the obligation to make this information further accessible to other users only in its original form,
- the obligation to inform about the processing of the re-used information,
- the scope of responsibility of the obliged entity for the information which it makes accessible.

The common practice previously observed in Poland - practically only in the case of the Public Information Bulletinine (BIP) - proves that public entities

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3 Dz.U. (Journal of Laws), 2011, no 204, item 1195.
concentrate only on points 1 and 4, and seldom mention the necessity to notify that the public information is to be processed. It is also worth mentioning that the author was so far not able to find an example of a publicly accessible API allowing to automate the downloading of public information, prepared and promoted by a public entity.

9.2. Access to information in the light of the intensive development of mobile technologies

An incredibly important factor, especially noticeable over the last several months, is a significant increase in the number of users of mobile devices (tablets and smartphones) and the accompanying phenomenon of a growing number of related services. It must be noted that these services very often involve providing selected types of information or monitoring or registering selected types of users’ activity. We are witnessing the development of new information needs and new habits of information acquisition. The user is no longer satisfied with the traditional access to the internet or the so-called “light” versions of his favourite information services. There is a growing demand for personalised information and on-line services supported by mobile devices in accordance with specified user profiles.

In this context, the web application Mobile City is an opportunity to propose and test a new philosophy of aggregating and sharing local information, in compliance with the European and Polish policy of obtaining and propagating public content. On the basis of the research conducted for the purpose of the project, a number of information areas were indicated concerning the basic groups of users of mobile technologies. Potential profiles of the use of these data were defined along with the access path to particular types of these data. At the same time, it appeared that in the case of tools offering information and services to local communities – in this case a metropolitalian city – the main partner with resources which may be used to construct prototype applications and services is the city and its organisational units.

9.3. The strategy for the development of Poznań by 2030 – the special place of the “E-city” programme and tasks implemented within it with particular emphasis on “the information broker”

The cooperation between the city of Poznań and academics from the Poznań University of Technology as part of the project “Integrated system supporting access to information in urban space” and in connection with the creation of the web application “Mobile City” was possible thanks to the consistent develop-
ment of the urban information infrastructure and thanks to making key strategic decisions. This resulted in the situation in which the academic partners were given access to information resources prepared in a way facilitating the implementation of the project.

Years of experience related to the construction of the information infrastructure in Poznań in cooperation with the Poznań academic and business environments associated for example in the Wielkopolska ICT Cluster (WKI) resulted in the development of a document defining the main directions for the development of this cooperation in the upcoming 20 years. This document is the strategic programme “Digital Poznań” which is an integral part of the “Strategy for the Development of the City of Poznań by 2030”4. Eight undertakings are planned to be implemented under this programme. The programme includes the suggestions for activities for the city based on information technologies meeting the challenges of the future. One of the assumptions of the programme concerns the use of the currently accessible and future ICT solutions and increasing the efficiency of the city management, as well as expanding the scope and improving the quality of services provided by the city. As can be easily seen, the implementation of the project “The Integrated support system for access to information in urban space” and in particular the development of the tool “Mobile City” perfectly corresponds to the concept included in Strategy 2030. For the purpose of this chapter, projects included in the “E-city” programme are mentioned; the “E-city” is one of the components of the “Digital Poznań” undertaking; the components have or may have a direct relationship with the project implemented by the Poznan University of Technology.

The aim of the project is to implement new solutions and ICT tools in order to improve the work of city units and to increase the standard of services in public offices, as well as to spread the knowledge about the city.

It is assumed that the project will make it easier to achieve the following:

- a greater work efficiency in municipal and city management units,
- a higher level of services in public offices,
- an easier and fuller access to information about the city (this is what the cooperation with the Poznań University of Technology under the project “The Integrated support system for access to information in urban space” concerns).

The main tasks to accomplish under the “E-city” project are:

1. the development of an integrated system of the city management with the use of information resources from urban organisational units (MJOs) and external entities with particular emphasis on the optimization and automation of information processes;

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(2) the finalization of the work on the electronic circulation of documents, based on open standards for data exchange, enabling transactional data exchange services between municipal organizational units and external systems of public administration and business;

(3) the transformation of the Municipal Multimedia Guide (MIM) and Public Information Bulletin (BIP) in the “information broker” system making it possible to collect content and implement it in external information services based on open standards (this is one of the goals of the project implemented in cooperation with the Poznań University of Technology);

(4) the development of the spatial information system (SIP), so that it becomes a source of specialist information about the city and of referential data useful in the investment processes and in spatial analyses;

(5) the consolidation and virtualisation of software and hardware resources of municipal organizational units (MJOs);

(6) the outsourcing of computer infrastructure of the municipal organizational units (MJOs);

(7) the digitalisation of the municipal organizational units’ archives;

(8) the implementation of advanced analytic tools in order to streamline the processes of monitoring and control of the municipal organizational units;

(9) the outsourcing of computer services;

(10) the implementation of the technology of data exploration in order to streamline the decision-making process and the management of the city;

(11) the implementation of a numerical map system updated by industry units;

(12) the optimisation of the information flow between source bases, state and local administration and entrepreneurs (e.g. construction projects).

As can be clearly seen, the tasks of points (1), (3), (4), (11) and (10) are directly related to the project of the Poznań University of Technology. Since the Strategy 2030 and the “E-city” programme have been based on previous experience and constant monitoring of changes and world trends, the planned tasks are already partially completed. Their effects, which will have a direct impact on the implementation of the R&D project undertaken in cooperation with the Poznań University of Technology, are described further in this article.

9.4. Previous experience and examples of implementation

As it has already been mentioned, the city of Poznań has for many years consistently developed computer infrastructure based on modern technologies. An example of this may be the Multimedia City Guide (poznan.pl) created in cooperation with the Poznań Supercomputing and Networking Centre (PCSS), which has become the centre for the municipal information broker mentioned in point (3) in the description of the “E-city” project. It is precisely the infrastructure of
this platform which will serve as a source of data for the Mobile City web application.

Today, the poznan.pl portal is a well-developed information and service platform, with technologies making it possible to automate the setting and distribution of data and content coming from the City Hall, municipal organisational units (MJOs) and external (institutional and legal) partners. Below are examples of content from the portal suitable for direct use in the Mobile City web application and indicated as desired by potential users during the research conducted for the purpose of the project.

- There are several dozen categories of Points of Interest (POI). These are different public utility objects, museums, cinemas, shopping centres, etc. Every category may be assigned with definable attributes, there is also a possibility to add galleries of photos and videoclips. The most important (from the perspective of the project) descriptive element of these objects is the possibility of their precise geolocation. The spatial location of each of them may be precisely described in two ways: through precise geographical identification of the address point downloaded automatically from the resources of the official spatial information system (SIP) held by the Board of Surveying, Cartography and Municipal Cadastre GEOPOZ (this is, in fact, the referential system used to specify information shared on the city portal) or through indicating the location on a digital map by the operator of the database belonging to a group of editors of the portal. It is worth adding that the portal’s resources are constantly expanded, with new spatial objects added (along with related basic information) into the system by municipal organisational units (MJOs) and verified for accuracy by city surveyors. Examples include: ticket machines, public transport ticket distribution points, parking meters, bus stops. The latter are automatically connected with the updated timetables. The access to this information is possible with the use of standardised www websites or a map interface.

- Nearly 20 categories of events, i.e. regularly completed calendar of events, concerts, etc. Also in this case it is possible to geolocate the described events through relating their descriptions to objects located in the database of the portal.

- Cinema and theatre showtimes – geolocation through the relations to Points of Interest (POI).

- Public transport timetables: according to the same principles as in the case of events.

It is worth mentioning that most data and content shared in the portal – and thanks to the data download interfaces also in other information services – can be (and is) complemented by internet users. The POI database and calendar of events are equipped with the system for adding content by users. Each such entry is, however, moderated by the portal’s moderators.
An important element expanding the accessibility if the portal’s content is automatic generation of QR codes leading to the mobile version of the urban portal. This concerns mainly the POI system, the calender of events and showtimes. The decision about introducing this way of presentation is a result of monitoring the development of mobile technologies and the evolution of behaviours of the portal’s users.

As it has already been mentioned in this Chapter, over the last several months it has been observed that more and more Poles use smartphones, tablets and other mobile devices. Also the experience of more developed countries confirms the increase in the interest in mobile devices. Therefore, works have already started to implement technologies into the portal which would allow to collect content and data in order to display it on mobile devices.

A very important feature of the city portal is that its information content is related to a referential map system. In the case of Poznań, it is the already mentioned SIP system held by GEOPOZ. Thanks to basing the cooperation on the automation of data exchange and the introduction of open presentation formats, it was possible to relate the previously separate resources of information. Some map information which can be publically shared was integrated with the city portal (which additionally gave a possibility to use the referential map resources for the proper geolocation of the portal’s resources) and is displayed within the portal; the SIP may be complemented with content from outside the municipal organisational units (MJOs), e.g. added by users.

It must be also mentioned that sharing map content and geolocation is directly related to the provisions of the Inspire Directive, although – naturally – on a local scale.

The implementations described above definitely facilitate the cooperation under the project “Integrated system supporting access to information in urban space”, also thanks to already gained experience in various ways of the aggregation and distribution of content of the city portal, which is treated as a foundation and core of the target city “information broker”. In order to complement the image of the portal as the core of the created system, we must also mention that for several years the selected content and services are available also thanks to such technologies and distribution channels as RSS, SMS or mobile versions of WWW pages. The use of these ways of presentation and servise provision has already given the poznan.pl portal its status of a multi-channel information and service platform.

The latest example of opening of the resources of poznan.pl and the Public Information Bulletin (BIP) issued by the Poznań City Hall, is sharing the APIs of selected parts of both of the information systems (in 2011). The decision was the result of legal requirements concerning the re-use of public information and also a local initiative to fulfil the recommendations of the Inspire directive; it is also an example of direct application of the provisions of the Poznań Strategy 2030. The city also attempts to attract potential customers to use the released
API to create new services. In October 2011, the so called hackathon of the poznan.pl API took place; as a result two new applications for mobile devices were launched onto the market. Moreover, a commercial enterprise started to use map sources to complement their information offer – it is one of the first examples of the direct implementation of the EU directive in Poland – thanks to an open API shared by a public unit.

All the undertakings and implementations involving fast distribution of content and – for several months – the open API of the poznan.pl portal and the Public Information Bulletine (BIP) are possible thanks to consistent use of open formats. The poznan.pl portal and the Public Information Bulletine (BIP) of the Poznań City Hall have for years operated in accordance with the W3C Recommendations. As part of the urban “information broker” project, open and undiscriminating formats are used for publishing, exchanging and coding data: RSS, GeoRSS, GML, OGG, Theora, JSON etc.

9.5. The project as a chance to improve the broker and a testing ground for new applications

The Mobile City application is a perfect complement to the described in this chapter experiences of the city of Poznań in constructing expanded information and service system based on the internet platform poznan.pl and the Public Information Bulletine (BIP). This undertaking has a double benefit – on the one hand, thanks to the tests on final users, the city has a better access to knowledge of the profile of urban information users who use mobile devices and is able to better shape its information offer, and develop it by adding new elements. It is also impossible not to mention another very precious element – the cooperation with the partner who, thanks to research and implementation works, may help to improve the API and to evaluate the qualitative value of the information it provides. Such cooperation will definitely contribute to improving methods and interfaces which the city uses to provide content and data. The project will result in an interesting proposal for an intuitive interface and content organisation for mobile devices, which may significantly contribute to the implementation of one of the tasks of the Poznań Strategy 2030.
Summary

In the monograph selected issues connected with implementation of the project „Integrated system for support of access to information in the urban space”, were discussed. The project has been presented for 10th competition of development projects and obtained funding on basis of a decision of the Minister of Science and Education from the 22.07.2010.

The monograph consists of nine chapters preceded by an introduction.

The Chapter 1: “Comparative analysis of the category of quality information”, written by Professor Ph.D., D.Sc., Eng. Władysław Mantura, Head of Chair of Marketing and Economic Engineering in the Faculty of Engineering Management at the Poznań University of Technology, has a theoretical character and it constitutes an introduction issues connected with information management. In this chapter, professor Mantura presents his own terminological concept, which shows that the idea of information is a fundamental category in the information theory. According to the author of the first chapter, unlike in many proposals from the literature of the subject, concepts such as communication, message, data and knowledge encompass the term information.

University Professor Andrzej Jaszkiewicz, Ph.D., D.Sc., Eng. from the Laboratory of Intelligent Decision Support Systems, Institute of Computing Science of the Poznań University of Technology, is the author of the Chapter 2: “Prospects for the development of mobile devices based on the use of GPS” and a member of the project team. His part of the monograph constitutes an introduction to the issues related to mobile devices. It shows directions and prospects for the development of these devices, with special attention paid to Smartphones. It presents data and forecasts for the market, as well as directions of scientific works. It also analyzes tendencies of development in the GPS technology, and most of all, its implementation in mobile devices and forecasts in reference to services and applications based on location.

The Chapter 3 called “Satisfying information needs in »The integrated support system for access to information in urban space« in the aspect of increasing the quality of life” presents author's original look at information needs in the context of quality, especially the quality of life. The author, Ph.D. Eng. Maciej Szafrański, from the Chair of Marketing and Economic Engineering in the Faculty of Engineering Management of the Poznań University of Technology, and member of the project team, interprets concepts of the term of quality and information needs in context of tasks implemented in the frame of this project. In author’s opinion, the integration of information about objects in the urban space
and the improvement of quality of such information would be a significant support for users in their processes of making decisions.

Assumptions related to the process of research were presented in the Chapter 4: “Methodology of research into information needs”. The author, Ph.D. Eng. Marek Goliński, from the Chair of Marketing and Economic Engineering in the Faculty of Engineering Management of the Poznań University of Technology, and member of the project team, describes research methods used in the process of preparing the system and the web application, which took place within the frame of this project. First, examinations of needs of users were presented. Next, synthetic results of qualitative and quantitative research that aim at identifying features of the information concerning the urban space, which are sought by target users of the system, were presented. Requirements referring to the verification of the preliminary version of the web application “Mobile City” were summarized. In the final part of the chapter, theoretical assumptions of research operations management were characterized.

The Chapter 5 entitled: “Principles of ergonomic interface design of a system for mobile use of information in urban space”, was authored by Ph.D. Waldemar Prussak, from the Chair of Ergonomic and Quality Management in the Faculty of Engineering Management of the Poznań University of Technology, and member of the project team. He described methods and ergonomic instruments that shape human-computer interaction. He presented the problem in a detailed way, using the very vast literature of the subject. In this system, the user interface constitutes the most important element; it encloses input-output devices and information. A significant part of the chapter presents principles and ergonomic guidelines applied while designing interface of systems providing mobile access to information.

The Chapter 6 – “Prototyping” was written by MSc. Eng. Magdalena Graczyk and MSc. Eng. Filip Kierzek from the Chair of Marketing and Economic Engineering in the Faculty of Engineering Management of the Poznań University of Technology, members of the project team. The chapter contains design fragments of the process of creating information system, which improve the system being created via application of the iterative methods of assessment and testing. Exemplary paper prototypes of screens, which constitute an illustration of steps of the use of the web application “Mobile City” were included. The process of prototyping was described in reference to particular screens and in reference to the test scenario related to the user’s search for required information.

The seventh chapter “Testing of the application and meeting the requirements”, by MSc. Eng. Magdalena Graczyk, is about verifying the level in which the key requirements of the information system have been fulfilled. Methodology of testing the application is described. The objective of these tests is to find errors of functionality and determine applications strengths and weaknesses. Ergonomics of the application interface, the content of information and deter-
mined functions and the graphical composition have been analyzed. On basis of these elements a general evaluation of the application was made. In result of test, the project team prepared an internal document “Presentation of modifications”, which serves for improving the web application, as well as the entire system.

The Chapter 8: “Description of the it subsystem in the Mobile City application”, written by MSc. Eng. Tomasz Skawiński, from the Chair of Marketing and Economic Engineering in the Faculty of Engineering Management of the Poznań University of Technology, member of the project team, constitutes a describes the structure and working principles of the web application created as part of the project. Special attention has been paid to equipment solutions, as well as the software of the web mobile application. Functionality of the designed web mobile application is described, by enumerating and describing most important benefits resulting from this solution, aimed at increasing the efficiency of access to the information.

The Chapter 9: “The Integrated support system for access to information in urban space – the place of the project in the context of local government’s vision of the development of information and service systems”, written by Wojciech Pelc – Head Manager of the Department of Information Services in the Poznań City Hall, presents possibilities of using the project in the functioning of public administration offices. The author described basic EU documents that establish principles of access to the widely interpreted public information and showed possibilities of using effects of the project. In his opinion, the solution prepared within frames of the project, can be helpful in the process of improvement already existing systems of service and information, based on the Internet platform. In the same time he declares that it can also serve as “testing ground” for new applications. The content of nine chapters of presented monograph through their diversity of subjects, whilst maintaining coherent objectives appropriately reflects the efforts made and task accomplished within the scope of this project.

Marek Goliński
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