Evaluation of PhD Thesis
Title: *Sensorial Networks embedded in Mobile Devices.*
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1 Introductory remarks

1.1 The formal basis for the preparation of evaluation

The evaluation was prepared at the request issued by the Dean of the Faculty of Informatics and Management, University of Hradec Králové, dated 27^{th} October 2015.

The domain classification of PhD dissertation declared in the letter of request is:

Study programme: *Applied Informatics*
Branch of study: *Applied Informatics.*

1.2 PhD Dissertation

The letter of request was accompanied with printed and electronic copies of PhD dissertation. The main bibliographic data of the dissertation are:

Behan, M., *Sensorial Networks embedded in Mobile Devices*, Doctoral Dissertation, University of Hradec Králové, Faculty of Informatics and Management, Department of Information Technology, Hradec Králové, 2015.

Language of dissertation: English

Number of pages (front matter): 8
Consists of: Title page; Acknowledgements; Author's declaration; Abstracts (English/Ćesky); Abbreviation list; Content.

Number of pages (main text): 97
Consists of: 9 chapters.

Other bibliographic details: Citations: 40; Figures: 45; Tables: 20.

2 The structure and content of dissertation

The thesis is organized into 9 chapters. Chapters 3-7 are devoted to a detailed presentation of essential results developed by the PhD Candidate. Introductory comments and definitions are given in Chapters 1-2 and a concluding discussion with final remarks in Chapters 8-9.

Chapters 1-2 include a general introduction to *R&D* problems, discussed further in main parts of the dissertation. Design, implementation and verification of a specialized software framework for smart systems' production is specified as the final product of the dissertation. Multiple *R&D* sub-issues are also enumerated and general description of final functionality of the framework is described. The basic technological and non-functional assumption is that sensors embedded in mobile devices should constitute an important component of smart systems produced within the final software framework.

Chapter 3 is devoted to a more extensive presentation of sensors technology. A special attention is given to the class of sensors embedded in mobile computational devices, available on the market. Multiple research, development and technical problems related to an integration of embedded systems, mobile devices and sensors are enumerated. The chapter includes qualitative analysis of the embedded sensors, as well as relates their functionality to the previously defined functionality of mobile technology - based smart systems. Developing of an effective merge of embedded sensors and mobile technologies is rightly pointed out as an important up-to-date research and development problem within the field of applied computer science. The conclusion from the overall presentation is as follows: the current state of technological development creates an apparent demand for universal software frameworks supporting integration of ambient intelligence computational processes and usage of mobile embedded sensors.

In Chapter 4 the Candidate presents an overview of existing frameworks, used to integrate the smart systems components with embedded sensors control and utilization. A qualitative analysis of just a few but apparently representative examples of software framework is carried out and resulting evaluations are presented. A detailed list of advantages and disadvantages is formulated for each of the considered frameworks. As a conclusion a summarized comparison is also proposed (see Tab. 10, page 30). An overall outcome of Chapter 4 makes it possible to further compare the Candidate's original proposal to the alternative solutions, available on the market.

In Chapter 5 the Candidate fulfills the following aims: brief, but sufficient, presentation of methodologies relevant to the chosen *R&D* targets of the project; detailed summarization of the desirable functionality of final framework, and presentation of the most important details of the final framework design. Chapter 6 gives a systematic presentation of implementation details and related issues. Chapters 5-6, as the whole, pull together the Candidate's major *R&D* results. These results are then related and confronted with the list of basic functional requirements, originally enumerated by the Author in Chapter 3.

Chapter 7 reports in a brief manner two relevant case studies: an application of the proposed software framework to designing and developing of a smart home and a public transport system.

Chapters 8-9 summarize all results and enumerate possible extensions and future developments.

Focusing the proposed framework on effective integration of sensors embedded in mobile components with smart technologies and cloud - related technologies is rightly pointed out by the Candidate as the key contribution of his doctoral dissertation.

3 Thesis Contribution

3.1 Thesis domain

The research problem defined and studied by the Candidate in his PhD Thesis belongs to the theory and practice of smart environments. There exist apparent references of the thesis to such areas of modern computer science as ambient intelligence, pervasive and cloud computing, as well as its less apparent connections to the field of computational semiotics and the concept of (cognitive) internet of things. **The PhD Candidate deals with up-to-date *R&D* problem that belongs to an intensively evolving sub-area of modern applied computer science.**

In order to properly understand the range of problems solved by the Candidate in his doctoral dissertation, it is necessary to take into account a very complex nature of actual smart systems. In particular, the following characteristics need to be considered:

At first, smart systems are situated in multiple classes of contexts, including contexts defined by end users and their broadly understood, usually complex social environments. Thus the actual contexts of smart systems are usually built from multiple computational processes and unstable objects, as well as created by real humans with their changing preferences, goals, and intentions.

At second, smart systems require advanced knowledge base management sub-systems for effective collecting, storing, processing and utilizing of usually heterogenous and rich data produced by surrounding physical and social environments.

At third, smart systems need to be equipped with advanced tools for the very complex integration of stored knowledge and data with processes carried out at the pragmatical level of smart systems applications.

The above three facts make the proposed PhD project a relatively complex, extensive and multidimensional *R&D* undertaking.

It is necessary to mention, too, that quite numerous examples of actual smart systems require rich volume of physical data (both current and historical) for their proper and effective functioning and work. The concept of Big Data is fully relevant here. The physical data in smart systems is usually collected by means of sensors, these days increasingly embedded in multiple stationary and mobile devices. Therefore in the forthcoming future it will be a common case that the working effectiveness of deployed smart systems depends substantially on accepted models of physical data gathering, storage, processing and utilization, all carried out in complex and distributed computational environments, accessible from various physical locations and by means of virtual networks.

Therefore for the latest few years, designing and developing of effective sub-systems for carrying out of physical data processing has become a target of substantially long list of *R&D* projects. However, it has to be strongly stressed that *only a small subset of these projects has been devoted to the creation of software frameworks dedicated to support smart systems design and implementation.* Developing, implementing and verifying of such a universal software framework to support the production of smart systems, with mobile embedded sensors and cloud technology components, has been chosen by the Candidate as the main *R&D* target of his thesis. **At the current state of smart systems technology development, I find this target as important and substantially contributing to the theory and practice of smart environments.**

In order to achieve his goal, the Candidate had to solve a rich list of detailed *R&D* problems, all of a very different nature and level of complexity. As the result the Candidate presented a complex, integrated set of software tools (a software platform) that supports the design, implementation and deployment of rich class of smart systems, to be situated in real physical worlds and used via virtual networks.

Similar software engineering tools are still very rare and, taking into account possible areas of smart systems application and current level of demand communicated by potential end users, often apparently ineffective regarding their computational capacity and substantially restricted regarding their desired functionality. It is sure that such lack of effective software engineering tools in the area of smart systems development will last for the next few years, as it was the case with now matured classes of similar software technologies. In consequence, at this state of the field development *R&D* projects similar to the Candidate's proposal are to be evaluated as original and apparently valuable, both technologically and pragmatically, and substantially contributing to the field of modern applied computer science.

3.2 Enumeration of original results

The general result of the thesis is **the development and verification of an original, functionally extensive, integrated software framework, capable of embedded sensors' control and utilization, supporting effective integration of new components of mobile and cloud technologies with intelligent systems technologies.**

A more detailed list of R&D results originally proposed by the Candidate can be stated as follows:

1. Qualitative analysis of the field:
   - extensive study of available physical sensors embodiment technologies,
   - qualitative analysis of available classes of mobile devices.
2. Extensive *R&D* results:
   - development of original framework functionality (requirements analysis and specification),
   - software design (designing of general architecture for the original framework, designing of original framework processes and databases/knowledgebases),
   - original framework implementation,
   - original framework verification and validation.
3. Applications:
   - original framework deployment,
   - developing of exemplary applications of smart systems,
   - functional verification of exemplary smart systems.

At the current state of the domain development, the above results, as the whole, constitute an extensive and complex body of original *R&D* contributions to the theory and practice of smart systems.

4 Discusion and Remarks

The evaluated manuscript is self contained and well prepared. The way the original results are presented is clear and fully acceptable, regarding its style and essential content. I find only the following general remarks necessary:

Remark 1. From the editorial point of view the manuscript has been prepared at a good level. The language is acceptable. However, there are various language mistakes, that has to be be removed, if the still unpublished parts of the dissertation are planned to be presented elsewhere.

Remark 2. A more detailed presentation of use cases would be welcome. Such enrichment of the original text would be especially interesting for potential users of the framework.

Remark 3. The list of relevant works, possible to be cited, could be extended in order to better underline the value of this original contribution. For instance, some references to general overviews of the current state of the art in the field of ambient intelligence and smart environments could spotlight the originality and value of the whole proposal and all detailed achievements. For instance, interesting overviews and presentations can be found in such serial publications as: *Journal of Ambient Intelligence and Smart Environments.*, *Journal of Ambient Intelligence and Humanized Computing*, etc.

Additionally, I find out that **the following practically important research question of potential applications of the framework to the area of applied computational semiotics can be raised.** It is quite obvious, that the effective interaction between end users and technical devices (including mobile devices) by means of quasi natural language statements, is a very important and still unsolved problem for the theory and practice of future smart systems technology. In my opinion the evaluated framework proposal does not seem to be very much helpful for the well known traditional corpus related linguistics, based mainly on statistical analysis of written language corpora. However, the framework corresponds in a very strong way to the field of cognitive linguistics, within which the concept of so-called cognitive semantics is taken into account. According to the cognitive semantics paradigm, all vocalized and/or written statements, produced by artificial and/or natural **autonomous** systems, need to be effectively grounded (anchored) in corpora of physical data. This corpora of physical data is, in fact, owned by communication-capable autonomous systems. It is this aspect of the natural language production, which seems to potentially supported in a very strong by the functionality of framework. in particular, it seems very probable that the framework can be effectively used to develop technical implementations of **autonomous** language production (grounded in physical data). My question is in what way the framework proposed by the Candidate can be used (or extended) to support the design and development of **autonomous rather than only intelligent components** of smart systems (smart environments). Autonomous language behaviour modelled by cognitive semantics and based on physical data corpora seems to be a practically valid and important context for a possible answer.

5 Final Conclusion

Considering the current state of the related domain development, the evaluated proposal contributes in an interesting way to the theory and practice of smart systems area, as well as other related fields of applied computer science.

At first, in his work, the Candidate solved a conceptually complex research problem of how to effectively integrate, within a unified software framework, physical data processing with higher levels of advanced computation (taking into account important aspects of newly developed mobile and cloud technologies). Such contribution is theoretically important and practically valuable, in particular for applied (technical) computer science.

At second, I find the evaluated results original and, as the whole, constituting a valuable *substantially extensive* large-scale *R&D* design and implementation work.

At third, from the methodological point of view the original *R&D* work realized by the Candidate was multidimensional, correct and complete.

At fourth, the presented dissertation proves the Candidate's extensive knowledge of the related scientific domain (both at its general and detailed levels).

At fifth, the dissertation is accompanied with reasonable collection of valuable and properly indexed papers, all authored and/or co-authored by the Candidate.

In conclusion, I find the submitted results as fulfilling the usual expectations accepted for doctoral dissertations classified in applied computer science (applied informatics). I recommend this dissertation for public defence and/or other legals steps provided under the law of academic degrees.

R. Kamm...