

A Pattern Language of Firefighting Frontline Practice to Inform the Design of Ubiquitous Computing

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Abstract

Designing computing systems for frontline firefighting is an open challenge. As of today, little computing support exists for such hazardous environments and designers struggle to build appropriate systems that fit the complex configuration on the frontline.

Following Christopher Alexander's understanding, design is about producing living transformations of existing configurations, it requires a thorough understanding of the situation on-site. Alexander introduces pattern languages as a means to describe existing configurations and to make them accessible for design, to link ethnography and design. This thesis therefore develops a pattern language of firefighters' activities at the frontline to transform the existing practice into a design space for computing support.

Grounded theory, as a qualitative method to identify patterns in empirical data, and action research, as a framework that allows studying the interaction between new technologies and existing practice, solidify the methodology of pattern research and are applied to conduct and analyze workshops with French and German firefighters at professional training facilities. Workshops comprise the observation of existing practice, the active participation in firefighting exercises and the introduction of novel artifacts.

Linked up as a pattern language, 16 patterns describe the configuration of frontline firefighting. The patterns detail how firefighters organize the division of roles and tasks, how they deal with information in a dynamic environment, how they form a social binding, improvise, provide safety and prepare their work.

While similar individual patterns have been described for firefighting and other high reliability professions, the pattern language, beyond these aspects, provides an integrated perspective on the frontline work; it allows developers to reflect technological concepts and supports the participatory design process of ubiquitous computing systems.

Dutch Abstract: Het ontwerpen van computer systemen om de brandweer te helpen bij de brandbestrijding is een enorme uitdaging. Op dit moment zijn er nog nauwelijks ondersteunende computersystemen om effectief te helpen in de gevaarlijke situaties waarin de brandweer regelmatig terecht komt. Onderzoekers vinden het uitermate lastig om goede ondersteunende computersystemen te ontwerpen die passen bij de complexe omgeving waarin de brandweer zich vaak bevindt. Volgens Christopher Alexander is ontwerpen in essentie het creëren van leefbare veranderingen van bestaande configuraties. Een goed ontwerp vereist daarom een gedegen inzicht in de praktijk. Alexander introduceert patronentalen als een middel om inzicht te verkrijgen in bestaande configuraties zodat het mogelijk wordt om deze configuraties te ontwerpen door verbindingen te leggen tussen etnografie en ontwerp.

Dit proefschrift ontwikkelt daarom een patronentaal voor de activiteiten van brandweermensen bij brand om zo de bestaande praktijk te vertalen naar een ontwerprijmte voor computerondersteuning. "Grounded theory" is gebruikt om patronen in de empirische gegevens te vinden en "Action research" is gebruikt als raamwerk om de interactie tussen technologie en bestaande praktijk te bestuderen. In professionele opleidingscentra zijn beide methoden toegepast om het gedrag van Duitse en Franse brandweermannen in bepaalde werksessies te analyseren. In deze werksessies werd de bestaande praktijk van brandweeroefeningen geanalyseerd en werd de impact van de introductie van nieuwe voorwerpen bestudeerd.

Uit onze conclusies blijkt dat 16 verschillende patronentalen gezamenlijk de configuratie van actieve brandbestrijding beschrijven. Deze patronen laten in detail zien hoe brandweermensen zich organiseren en rollen en taken verdelen, hoe zij omgaan met informatie in een dynamische omgeving, hoe zij sociale relaties vormen en hoe zij improviseren, veiligheid verzorgen en hun werk voorbereiden.

Hoewel eerdere studies vergelijkbare individuele patronen hebben beschreven voor het bestrijden van brand en andere beroepen waar een hoge betrouwbaarheid vereist is, is deze patronentaal uniek omdat het een integraal perspectief biedt op het werken in de vuurlinie. Het biedt ontwerpers de mogelijkheid om technologische concepten te testen en ondersteund participatie in het ontwerpproces van alomtegenwoordige computersystemen.

Acknowledgements

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Related Publications

The research described in this work has partly been previously published, presented and discussed with scientist in the fields of Human-Computer Interaction, Design and Safety-Critical Information Technology. The following list provides an overview of the articles published and describes their contents and their relation to this work.

Full Papers

- Denef, S., and Keyson, D.V., Talking about Implications for Design in a Pattern Language, SIGCHI Conference on Human Factors in Computing Systems. CHI'12, 2012, ACM, under revision.

This paper presents the results from the introduction of the pattern language to developers as a means to reflect on its implications for design.

- Denef, S., Oppermann, R. and Keyson, D.V., Designing for Social Configurations: Pattern Languages to Inform the Design of Ubiquitous Computing, in International Journal of Design, accepted pending minor revisions.

This paper presents the methodology and overall pattern-based approach of this thesis. It also presents a summary of the resulting pattern language and its link to the design case.

- Denef, S., Keyson, D.V., and Oppermann, R., Rigid Structures, Independent Units, Monitoring: Organizing Patterns in Frontline Firefighting, in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. CHI'11, 2011, ACM: Vancouver, Canada. 1949–1958.

This paper presents RIGID STRUCTURE, INDEPENDENT UNITS and MONITORING as interacting patterns of the overall configuration of firefighting frontline practice and discusses their relation to the design of ubiquitous computing artifacts.

- Denef, S., Ramirez, L., Dyrks, T., and Stevens, G., Handy Navigation in Ever-Changing Spaces: An Ethnographic Study of Firefighting Practices, in Proceedings of the 7th ACM Conference on Designing Interactive Systems. DIS'08, 2008, ACM: Cape Town, South Africa. p. 184–192.

This paper brings together the results from the ethnographic investigation and the introduction of the Digital Command Post system at the Parisian Firefighters. With its focus on frontline navigation practices, it presents aspects of the work that in this thesis become part of the patterns INDEPENDENT UNITS, MULTIMODAL ACTS, and MASH-UP.

- Dyrks, T., Ramirez, L., and Denef, S., Designing for Firefighters—Building Empathy through Live Action Role-Playing, in Abstracts of the International Conference on Information Systems for Crisis Response and Management, ISCRAM’09. 2009: Gothenburg, Sweden, May 10–13, 2009. **This paper presents the role-playing workshops with the firefighters and the empathic approach that is part of this work’s methodological concept.**

Short Papers

- Denef, S., Ramirez, L., and Dyrks, T., Letting Tools Talk: Interactive Technology for Firefighting, in Extended Abstracts of the SIGCHI conference on Human Factors in Computing Systems, CHI’09. 2009, ACM: Boston, MA, USA. p. 444–447.

This work-in-progress report presents results from the study on the tools of firefighters described in the HANDY MULTI TOOLS pattern.

- Ramirez, L., Denef, S., and Dyrks, T., Towards Human-Centered Support for Indoor Navigation, in Proceeding of the Twenty-Seventh Annual SIGCHI Conference on Human Factors in Computing Systems CHI’09. 2009, ACM: Boston, USA. p. 1279–1282.

The relation between the navigation support system presented in this note and the pattern language is part of the discussion of this thesis. Additionally, the design of the system drives the design-oriented research activities.

Workshop Contributions

- Denef, S., A Pattern Language of Firefighting Frontline Practice to Inform the Design of Ubiquitous Computing. Doctoral Consortium Intl. Conference on Ambient Intelligence. AMI’11. 2011. Springer. forthcoming

This note presents the research questions and approach of this thesis.

- Denef, S., Ramirez, L., and Dyrks, T., A Deep Dive into the World of Firefighters, Presented at the Bridging the Gap Workshop of the SIGCHI Conference on Human Factors in Computing Systems (Atlanta, GA, USA, April 10–15, 2010). CHI'10. 2010.

This position paper proposes the use of ethnographic, empathic and design-oriented research as a means to prepare the jump between user research and design activities as proposed in the discussion.

- Denef, S., Human-Computer Interaction Techniques in Firefighting, Doctoral Consortium. in Human-Computer Interaction–INTERACT'09. 2009, Springer. p. 864–867.

This position paper argues for an ethnographic research approach in designing human-computer interaction techniques for firefighters.

- Dyrks, T., Denef, S., and Ramirez, L. An Empirical Study of Firefighting Sensemaking Practices to Inform the Design of Ubicomp Technology. Presented at the Sensemaking Workshop of the SIGCHI Conference on Human Factors in Computing Systems (Florence, Italy, April 5–10, 2008) CHI'08. 2008.

This position paper presents sensemaking practices of frontline firefighting work some of which are covered by the EVER-CHANGING PUZZLE and MASH-UP patterns.

Other Publications

- Denef, S., The Second Step: Learning from Firefighters about Good Management. Global Peter Drucker Forum 2011, Vienna, Austria. forthcoming (4. Prize, Essay Competition “Management what is it good for?”)

This essay puts the firefighting practice described in the pattern language into the context of Peter Drucker’s research on management and explains what managers of other professions can learn from firefighters about management.

- Scholz, M., Scholl, P., Busse, M., Stoetzer, M., Budde, M., Shishkova, D., Riedel, T., Beigl, M., Ramirez, L., Denef, S., Betz, M., and Dyrks, T., Video Submission: A MVC Prototype for the landmark Firefighter Navigation System, in Internet of Things Conference 2010: Tokyo, Japan.

This video presents the design of the navigation support system and sets it in context to frontline firefighting practice.

Foreword by the Institute Director

At the Fraunhofer Institute for Applied Information Technology FIT we investigate human-centered computing to optimize the usefulness of information and cooperation systems in their interplay with human work practice and organizational processes.

The emergency management domain is a typical example. It is presently characterized by its complex requirements and—to a large extent—the absence of IT support on the frontline. As one key example, Fraunhofer FIT has taken up the challenge to support first responders in firefighting. The European project WearIT@Work has performed research on wearable computing systems for this domain, and developed both planning methodologies and initial artefacts for navigation. The BMBF project ‘landmarke’ has expanded the design towards a navigation support system for frontline firefighters which also forms the technical kernel of the thesis by Sebastian Denef. The European project SOCIONICAL investigates larger-scale firefighting settings, and BRIDGE aims to support large-scale crises across national and organizational boundaries.

Based on experiences in these projects, several doctoral theses at Fraunhofer FIT have been investigating firefighter work practices with different methodologies, and developing methodologies and specific solution proposals for advanced technologies.

The thesis by Sebastian Denef makes two contributions. Firstly, by case studies from his participation in three of the mentioned projects, it contributes towards an improved empirical foundation for understanding firefighting practice. Secondly, it takes a novel approach for human-centered design processes, connecting ethnographic research with the design of IT systems. With the emergence of ubiquitous computing systems, traditional approaches of capturing and modeling work processes often ignore a larger social dimension that gains an increasing importance when computing becomes embedded into objects of everyday life. Understanding human practice and its relevance for the design of IT systems is an open research question that requires an interdisciplinary answer from social and engineering sciences. Here, the development and use of pattern languages, as proposed by Sebastian Denef, builds a promising bridge between ethnographic user

studies, and the design of IT systems, here specifically novel navigation systems for firefighters.

The reader thus gains an in-depth perspective of the fascinating work of frontline firefighters and the challenge of designing of IT systems that support their work; she also learns of an approach that connects our understanding of human practice with the task of IT design and is therefore relevant for the general challenge of human-centered design of computing systems.

Aachen and Sankt Augustin, October 2011
Matthias Jarke, Fraunhofer FIT

Die Institute des Fraunhofer-Verbunds Informations- und Kommunikationstechnik (IuK) entwickeln gemeinsame Strategien für die anwendungsorientierte Forschung.

In der Reihe „Fraunhofer Series in Information and Communication Technology“ publizieren die IuK-Institute Dissertationen, Habilitationen sowie herausragende Diplomarbeiten, wissenschaftliche Monographien und Forschungsberichte. Diese Publikationen dienen der Fundierung der anwendungsnahen Fraunhofer-spezifischen Forschung und Vorlaufforschung.

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A Note to the Reader

To support the reader, I added abstracts at the beginning of each chapter and marked sentences bold that summarize the following paragraphs. Should you want to read this work within less than an hour, you may choose to flip through the pages and only read these abstracts and the sentences in bold.

This approach of writing is inspired by Christopher Alexander (1979) who argued that for the designer an overall understanding is more valuable than the knowledge of scattered details.

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