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Emergence as a Characteristic of Resilient Cooperation Technologies

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1. Introduction: coming together is a beginning

Together many things are easier: "*Coming together is a beginning; keeping together is progress; working together is success*" (Henry Ford). Nowadays, this cooperation is not just possible if the collaborators meet face to face, but also using cooperation technologies. The progress of the past decades has enabled infrastructures for better communication, cooperation and collaboration beyond spatial, temporal and organizational boundaries [1]. This is true for many domains, such as industry, research and also for disaster response. Accordingly, enterprises exchange data on the flow of material and information through the help of supply chain management systems to coordinate their value-adding processes. Scientists from different universities work together on research proposals and articles using collaborative systems like Dropbox, OneDrive, SharePoint or GoogleDocs. Authorities and organizations with duties concerning public security - as emergency services - also exchange relevant information during major incidents.

IT-systems as resulting artifacts can support this. The collaboration is typically described and regulated by processes and specifications based on the defined context [2]. However, if the actual situation differs too much from the previously made assumptions or specifications - which means that the actual context has too many differences from the originally defined context - it is possible that collaboration cannot be supported as needed. "Early CSCW scholars usefully drew attention to the gap between the formalized representations of organizational processes […] of the user organization and its complex, heterogeneous and difficult to formalize practices" [3]. As a part of the work infrastructure, IT has to consider this emergent nature of the work environment to support the collaboration even in such emergent situations, where spontaneous and ad hoc collaboration [4] is needed and new as well dynamic structures occur.

In this article we discuss the characteristic of "*emergence*" for collaboration technologies in order to create resilient cooperation technologies.

2. Emergence: arising of novel structures which are impossible to predict

The previously mentioned term *emergence*, lat. emergere (to emerge), was shaped by the philosopher George Henry Lewes. Reuter [5] discusses this concept in terms of infrastructures for crisis management: Accordingly, many items are just the summation of or the subtraction of the influencing factors [6]. However, this is not the case for *emergent* items which cannot be reduced to this. Emergence is understood as the arising of novel structures, patterns and properties during the process of self-organization in complex systems, which are impossible to predict entirely before they actually arise [7]. This development of

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structures can (at least partly) be supported through collaboration infrastructures. While a few decades ago support for collaboration was only possible through proprietary tools this has changed through the increasing use of e-mail, collaborative systems, mobile devices and social media, even so that supporting emergent collaboration is partly possible [8]. Therefore, not only official systems are understood as *work infrastructure* but also the entire set of devices, tools, technologies, standards, conventions and protocols an individual or a collective relies on in their work practice [9]. In general, the assumption is that technologies that allow emergence are well prepared to contribute to the resilience of the system. However, how can such technologies support resilience?

3. Resilience: mastering difficult situations without persistent impairments

Resilience is of great relevance especially in systems that are stable. Not least the *paradox of vulnerability* emphasizes the importance: Every disturbance has a stronger effect to the extent of stability (and therefore less susceptibility) in its supply services [10, p. 10]. Differentiated organization structures that are habituated to very high security standards as well as to a high security of supply use robust and complex technologies and are this particularly vulnerable to disruption. For example, in many countries electronic power is perceived as a given ubiquitous resource. The enormous extent of this first becomes apparent in cases of power failure [11]. With increasing robustness and decreasing susceptibility, a deceptive feeling of safety develops and the effects of an incident can be disproportionately high [10, p. 10]. However, robust technologies can contribute towards strengthening resilience by using disruptions of infrastructures as a trigger to update and improve the infrastructure [9].

The term *resilience* (lat. *resilire* 'jump back') has multiple meanings and includes resistance as well as the ability to withstand difficult situations in life without persistent impairments. Reuter [12] discusses this term for the domain of crisis management. In spite of the large number and the range of definitions, there is a consensus with regard to two fundamental aspects [13]: Firstly, resilience must be seen as a process rather than as a result. Secondly, resilience is preferably conceptualized in terms of adaptability than in terms of stability. De facto stability can constitute a lack of resilience in some cases in accordance with an insufficient ability to change. *Disaster resilience* is defined as the ability to cope with the conversion by maintenance transformation without long-term consequences [14]. Even though actors in disaster situations like to return to a previous state, uninfluenceable changes of the physical, social or psychological reality can make this impossible, especially in the context of disasters [15].

As long as most infrastructures are used by groups of people, concepts taking cooperation into account are of importance. The concept of *social resilience*, which also emerged in the context of disaster situations, includes the capacity of social groups and communities to recover from crisis situations or to react to them in a positive manner [16]. This is based on the supporting characteristics of resistance (preventing disasters), restoration (expeditiously repairing possible disasters) and creativity (learning from disasters followed by improving the system state). Social media can be used as a tool for it [17]. Based on this, Reuter et al. [12] define *cooperative resilience*. Cooperation, lat. *cooperatio* (*co* = together; *operatio* = work), is a practice of working together. Correspondingly, their understanding of resilience by cooperation is the ability to come through crises by means of adaptability to changed realities without sustainable disaster by cooperating. Accordingly, *cooperative resilience,* however, is the ability to come through

'crises of cooperation' (that means failure of cooperation possibilities) by *adaptability to cooperation tools*.

4. *Emergence* for resilient collaborative technologies

This adaptability, flexibility or in general "emergence" has also been identified as a key requirement for resilient cooperation infrastructures. Based on empirical studies of emergency services such as police and fire departments, public administration and energy network operators in two regions in Germany [5], we found many emergent and improvised work practices [18]. Even if they were only explained after specific questioning it became obvious that all work practices are flexible, even if in one district formal process were referred to especially. Since every situation seems to be different, the execution of a process has to be improvised. Here, they distinguished between emergency services and public administration since the result was mentioned to be most important and not the formal correct execution of processes.

Taking these findings into consideration, emergent practices demand collaborative infrastructures which enable spontaneous and informal collaboration and supports official work processes. An organizational social network (SiRena) [12] was developed as well as different prototypes based on it, as a web-based situation map (ISAC) [19], an Android-based collaboration-app (MoCo) [4] and another Android-based reporting-app (MoRep) [20], each trying to ease the technical support of emergent collaboration needs in dynamic situations.

These concepts aim to create flexible and robust IT-artifacts that enable the users to handle problems and that contribute not just to the resilience of the collaboration technologies, but also for the resilience of the overall system. Finally, we argue that "emergence" is one of the key characteristics in order to archive resilience and emerging solutions have to address it in order to be successful.

References

[1] G. Doherty, N. Karamanis, and S. Luz, "Collaboration in Translation: The Impact of Increased Reach on Cross-organisational Work," *Comput. Support. Coop. Work J. Collab. Comput.*, vol. 21, no. 6, pp. 525–554, Aug. 2012.

[2] F. M. I. Shipman and C. C. Marshall, "Formality Considered Harmful: Experiences, Emerging Themes, and Directions on the Use of Formal Representations in Interactive Systems," *Comput. Support. Coop. Work J. Collab. Comput.*, vol. 8, no. 4, pp. 333–352, 1999.

[3] E. Monteiro, N. Pollock, O. Hanseth, and R. Williams, "From Artefacts to Infrastructures," *Comput. Support. Coop. Work J. Collab. Comput.*, vol. 22, no. 4, pp. 575–607, Jun. 2013.

[4] C. Reuter, T. Ludwig, and V. Pipek, "Ad Hoc Participation in Situation Assessment: Supporting Mobile Collaboration in Emergencies," *ACM Trans. Comput. Interact.*, vol. 21, no. 5, 2014.

[5] C. Reuter, *Emergent Collaboration Infrastructures: Technology Design for Inter-Organizational Crisis Management (Ph.D. Thesis)*. Siegen, Germany: Springer Gabler, 2014.

[6] G. H. Lewes, *Problems of Life and Mind*. London, United Kingdom: Osgood, 1875.

[7] J. Goldstein, "Emergence as a Construct: History and Issues," *Emergence*, vol. 1, no. 1, pp. 49–72, Mar. 1999.

[8] C. Reuter, "Emergente Kollaborationsinfrastrukturen – Technologiegestaltung am Beispiel des inter-organisationalen Krisenmanagements," in *Ausgezeichnete Informatikdissertationen 2014.*

GI- Edition-Lecture Notes in Informatics (LNI), D-14, S. Hölldobler, Ed. Bonner Köllen Verlag, 2015, pp. 209–218.

[9] V. Pipek and V. Wulf, "Infrastructuring: Towards an Integrated Perspective on the Design and Use of Information Technology," *J. Assoc. Inf. Syst.*, vol. 10, no. 5, pp. 447–473, 2009.

[10] Bundesministerium des Inneren, *Nationale Strategie zum Schutz Kritischer Infrastrukturen (KRITIS-Strategie)*. Berlin, 2009.

[11] C. Reuter, "Communication between Power Blackout and Mobile Network Overload," *Int. J. Inf. Syst. Cris. Response Manag.*, vol. 6, no. 2, pp. 38–53, 2014.

[12] C. Reuter, T. Ludwig, and V. Pipek, "Kooperative Resilienz – ein soziotechnischer Ansatz durch Kooperationstechnologien im Krisenmanagement," *Grup. Interaktion. Organ. Zeitschrift für Angew. Organ.*, vol. 47, no. 2, pp. 159–169, 2016.

[13] F. H. Norris, S. P. Stevens, B. Pfefferbaum, K. F. Wyche, and R. L. Pfefferbaum, "Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness," *Am. J. Community Psychol.*, vol. 41, no. 1–2, pp. 127–150, 2008.

[14] UK Govenment: Department for International Development, "Defining Disaster Resilience: A DFID Approach Paper." Department for International Development, London, UK, pp. 1–20, 2011.

[15] D. Paton and D. M. Johnston, *Disaster resilience: an integrated approach*. Charles C Thomas Publisher, 2006.

[16] B. Maguire and P. Hagan, "Disasters and communities: Understanding social resilience," *Aust. J. Emerg. Manag.*, vol. 22, no. 2, pp. 16–20, 2007.

[17] C. Reuter and T. Spielhofer, "Towards Social Resilience: A Quantitative and Qualitative Survey on Citizens' Perception of Social Media in Emergencies in Europe," *J. Technol. Forecast. Soc. Chang.*, vol. in press, 2016.

[18] B. Ley, V. Pipek, C. Reuter, and T. Wiedenhoefer, "Supporting Improvisation Work in Inter-Organizational Crisis Management," in *Proceedings of the Conference on Human Factors in Computing Systems (CHI)*, 2012, pp. 1529–1538.

[19] B. Ley, T. Ludwig, V. Pipek, D. Randall, C. Reuter, and T. Wiedenhoefer, "Information and Expertise Sharing in Inter-Organizational Crisis Management," *Comput. Support. Coop. Work J. Collab. Comput.*, vol. 23, no. 4–6, pp. 347–387, 2014.

[20] T. Ludwig, C. Reuter, and V. Pipek, "What You See Is What I Need: Mobile Reporting Practices in Emergencies," in *Proceedings of the European Conference on Computer Supported Cooperative Work (ECSCW)*, 2013, pp. 181–206.