Workshop on the Control of Systemic Risks in Global Networks (SysRisk2019 - as part of the 14th International Conference Wirtschaftsinformatik)

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Abstract. The emergence of global networks also results in the occurrence of systemic risks that might affect the stability of the overall system. To cope with these risks, this workshop on the "Control of Systemic Risks in Global Networks" (SysRisk2019) provides a platform for the collection and discussion of innovative approaches, methods, and theories but also of practical problems from the areas of simulation, artificial intelligence, operations research, and statistics. This enables the exchange of experiences and methods between scientists and practitioners. The SysRisk2019 workshop has taken place as part of the 14th International Conference Wirtschaftsinformatik (WI2019) in Siegen, Germany on February 24th 2019.

Keywords: Grand Challenge, Systemic Risk, Reference Framework.

1 Introduction

Modern communication networks lead to a stronger coupling of and interdependency between social and economic areas. Examples are electronic marketplaces, which enable ever faster transactions, worldwide production networks, which allow for higher specialization with increasing efficiency, and *smart grids*, which facilitate the provision of energy in the European Single Market by means of flexible control. The resulting worldwide and interconnected networks increasingly decide on the competitiveness of enterprises.

On the one hand, this development is promoted by a strong **demand pull** for innovative technologies that emanates from companies. This results from the companies' endeavor to take advantage of environmental differences in a "globalized world". Examples are increasing sales opportunities in emerging countries, low labor costs, special competences in the development and production of electronic components or software products, discoveries of raw materials, and tax conditions.

On the other hand, there is an increasing **technology pressure**. This is due to an increasing performance-cost ratio of data management as well as from the fact that modern multi and manycore systems accelerate or initially enable the solving of sophisticated planning, disposition, and control algorithms. Moreover, the advancement of traditional methods, e.g., artificial neural networks and deep learning, allows for the discovery of patterns and the investigation of systems that remained hidden or were inaccessible before.

Along with these worldwide networks, *systemic risks* emerge which affect the stability of the overall system [1]. Examples of potential failures are flash crashes in high-frequency trading, production downtime due to delivery delays, or blackouts in energy networks. For instance, on September 28th, 2003, power plant failures in Italy lead to disruptions of the Internet infrastructure, which relied on energy supply and at the same time was required to control other power plants. This resulted in a cascade of failures and has nearly caused the collapse of the entire Italian energy supply [2,3].

Obviously, not all risks are equivalent with respect to their probability of occurrence and of the consequences. Thus, those *systemic risks* must be identified, which – as illustrated by the example – affect the stability of the overall system and are not considered as part of the risk assessment of the independent subsystems. Here, the extent of the risk must be considered as well as the probability of finding an adequate countermeasure with reasonable effort.

In a joint initiative, which is steered by the *German Informatics Society* (Gesellschaft für Informatik e.V.; GI), Information Systems Research and Computer Science have selected the *control of systemic risks in global networks* as one of the five most important Grand Challenges for the future [4]. From an information system research perspective, two major interests can be identified: On the one hand, the availability as well as the situational aggregation and interpretation of decision-relevant information and on the other hand the autonomous identification, quantitative estimation, and flexible reaction to risks. To provide a forum for the presentation and discussion of respective approaches, the *SysRisk2019* workshop has been arranged as part of the 14th International Conference Wirtschaftsinformatik (WI2019) in Siegen, Germany on February 24th 2019. In this paper, current challenges and trends that lead to this workshop as well as the reference framework was used for the classification and discussion of approaches are outlined [5]. Moreover, the structure of the workshop is presented and all contributions that were made are briefly introduced and related to each other.

2 Current Technology Pressure

In information system as well as computer science research, there are ongoing discussions whether networks can be designed or dynamically emerge from the interaction of devices with network technologies: Worldwide networks are not designed as part of an “engineering process”, they are created through the interaction of interconnected systems as emergent phenomenon and must be described and understood [6].

The need for a development of methods for the design of such networks can be identified when investigating the current technology pressures. Developments that can contribute to the control of systemic risks include but are not limited to:

1. **Communication Networks**: Advances in communication networks, e.g., an increasing performance-cost ratio of communication channels (hardware) and greater flexibility in routing (software), which allow for prioritized communication in case of emergency.
2. **Simulation**: Recent developments in simulation from a tool for planning support to a real-time assistance for decision support through the development of innovative formalisms, e.g., system dynamics or agent-based simulation, and due to the immediate availability of current data.
3. **Machine Learning**: Revolutionary progress in machine learning that is facilitated by the increasing availability and amount of (training) data as well as shift from multi to multi and manycore computing. This allows for the use of deep learning, convolutional neural networks as well as data, text, and opinion mining techniques.
4. **Decentralized Control**: The availability of approaches for decentralized and adaptive control with autonomous software agents, multiagent systems, and organic computing promotes the high-tech strategy "Industry 4.0".
5. **Transaction Processing Systems (Blockchain)**: New forms of transaction processing systems, e.g., blockchain, allow for the tamper-resistant and decentralized organization and logging of safety-critical operations in processes such as access or updates of sensitive data.
6. **Multilayer and Multiplex Networks**: A shift from the analysis of isolated and homogenous networks to the investigation of multilayer and multiplex networks (interdependent networks).
7. **Convergence**: The convergence of technical systems and processes leads to the unification of business models and technologies across sectors. Through this, technical and economic success of one domain might dominate another domain, e.g., successful business models of internet giants can compete with stationary trade in the physical world even though the horizon of experience is considerably lower.

Due to disciplinary barriers, the aforementioned technology areas are not yet sufficiently developed, applied, or transferred for controlling systemic risks. This limits the opportunities for action that can be undertaken to prevent the potentially dramatic consequences of systemic risks. Still, these technologies have a high potential to contribute as component of a solution for controlling systemic risks.

Considering disaster management strategies, for instance, it can be illustrated how disciplines can learn from each other and benefit from the experiences of other disciplines. Insurance companies make use of reinsurances to handle major claims which could result in their insolvency. Such approaches are also applicable to supply chain management as protection against supply shortages that might result in disruptions of the own production of goods. In this regard, supply chain management

can also learn from insurances as systemic risks emerge from networks of reinsurances which can potentially result in uncontrollable chain effects that lead to global crises.

3 Reference Framework

Suitable technologies and methods for controlling systemic risks are diverse. Thus, to classify and distinguish different approaches, we suggest the use of a morphological box. It serves as a reference framework for discussion within the workshop as approaches can be classified and assessed according to different dimensions. In Figure 1, the morphological box is illustrated that is used for the assessment of the approaches that are presented as part of this workshop. For each approach, the aspects of *networks*, *risks*, and *decision situation* are focused.

To this end, the domain focus of the workshop lies on *logistics*, *finance & insurances*, and *public services*, yet, also contributions from other domains are welcome. With respect to the type of risk that is addressed by the approaches, it can be differentiated into five types, according to the domain the risk is related to: *production*, *market*, *finance*, *institution*, and *nature*. In addition, also the occurrence of the risk is classified as *regularly*, *periodically*, or *rarely*. Finally, the decision situation of the risk can be specified according to the risk's predictability as well as by the authority which is the decision maker.

Network	***Domain***	Logistics		Finance & Insurances		Public services
	Network model	Available and fixed	Available and ongoing change	Situation-dependent change		Ad-hoc
Risk	***Type of risk***	Production	Market	Finance	Institutional	Nature
	Occurrence	Regularly		Periodically		Rarely
Decision situation	***Predictability***	Predictable and plannable	Predictable and not plannable	Not predictable but plannable		Not predictable and not plannable
	Authority	Single person	Committee	Automated, with intervention of persons		Fully automated
	Horizon	Enterprise		Network		Society

Figure 1: Reference framework for the classification and discussion of approaches.

4 Contributions to the Workshop

To address the Grand Challenge of controlling systemic risks in global networks, this workshop aims at both the collection and discussion of innovative approaches, methods, and theories but also practical problems from the areas of simulation, artificial intelligence, operations research, and statistics. To this end, the goal of the workshop is to provide a platform for the exchange of experiences and methods between scientists and practitioners. Moreover, the development of a medium-term research agenda shall be promoted for targeting this Grand Challenge.

As part of the SysRisk2019 workshop, 17 presentations were given providing different perspectives on systemic risks in global networks. According to their focus, the contributions were assigned to three different sessions: “Analyzing Worldwide Networks”, “Design of Processes and Networks”, and “Risk and Crisis Management”. Finally, in a fourth final session, the approaches and results from all previous sessions were consolidated and related in a group discussion.

4.1 Analyzing Worldwide Networks

As part of the session “Analyzing Worldwide Networks”, four papers have been presented. Most of the presented papers discuss the use of computer simulation as method to investigate and analyze different aspects of global networks. In their paper “Towards Systematic Testing of Complex Interacting Systems”, René Schumann and Caroline Taramarcaz introduce a notion of adaptive systems, which can change their behavior at run-time. They outline that such systems create a new type of error-behavior for which conventional techniques cannot be applied and propose a structured simulation framework to test the behavior of adaptive systems.

Due to the complexity and close connection between networks used in daily life, systemic risks might occur. To prevent negative effects of these risks, Sören Bergmann, Niclas Feldkamp, and Steffen Straßburger suggest in their paper “Wissensentdeckung und Robustheitsanalyse für Simulationsmodelle weltweiter Netze” (“Knowledge Discovery and Robustness Analysis for Simulation Models of Global Networks”) to ensure robustness already during the design of networks. Therefore, the authors propose a data-farming based method for conducting robustness analysis in the domain of manufacturing. For adapting the proposed method to complex networks, various research needs are presented.

The paper “Behavior Mining Methods for Dynamic Risk Analysis in Social Media Communication” by Jan Ole Berndt considers systemic risks of social media with respect to crisis and reputation management. Behavior mining is introduced for analyzing communication processes which result from individual behaviors of interconnected users.

Finally, the paper “Cryptocurrency Crashes: A Dataset for Measuring the Effect of Regulatory News in Online Media” by Achim Klein, Lyubomir Kirilov, and Martin Riekert extend prior research on effects of regulatory news on cryptocurrency markets, to analyze the effects of restrictions of usage or even complete bans of cryptocurrencies. To measure the effect of regulatory news on cryptocurrencies, a dataset of online media news for application to empirically study the effects on Bitcoin pricing is presented.

4.2 Design of Processes and Networks

As part of the second session on “Design of Processes and Networks”, five papers were presented. In their paper “Structural Change in Insurance: The Emergence of Comprehensive Value Networks” Albrecht Fritzsche and Alexander Bohnert investigate the convergences of business activities across different sectors of critical infrastructure and identify two distinctive patterns of convergence. The focus of their

investigation is set to insurance industry, which has proven openness for new types of offerings and business models as part of the digital transformation.

Sebastian Lehnhoff and Astrid Nieße propose an approach to derive relevant solution parameters for optimizing distributed business processes and integrating the parameters into existing supervisory automation and control concepts. In their paper "Event-driven Reorganization of Distributed Business Processes in Electrical Energy Systems", they apply event-driven reorganization and multi-agent systems to find a solution in time and to handle a large number of conflicting objectives.

Together with Frank Eggert, Astrid Nieße and Sebastian Lehnhoff contributed a second paper to the workshop: "Managing Conflicting Interests in Socio-technical Energy Systems – How to Identify and Mitigate Intra-actor Interests as Risk Factors., Here, they discuss two contradictory paradigms, i.e., complexity reducing and complexity increasing measures, to ensure stable operations in global networks. It is shown why intra-actor conflicts arise from adding both complexity and reducing transparency at the same time. The authors propose a research agenda and present existing approaches and open issues regarding an abstract model of decision conflicts, a dynamic model to evaluate the effect of transparency changes during runtime, and metrics to evaluate degrees of autonomy and transparency in the context of energy systems.

The paper "Ein hierarchischer Ansatz des Risikomanagements zur Gestaltung robuster Liefer- und Transportnetzwerke" ("A Hierarchical Risk Management Approach for the Design of Supply and Transport Networks") by Patricia Rogetzer and Stefan Minner proposes a two-step hierarchical planning approach to design supply and transport networks. By this means, more resilient networks can be designed as proactive and reactive methods prevent the network from disturbances and interruptions.

Gilbert Fridgen and Martin Weibelzahl discuss the potential contributions of Blockchain technology to systemic risk management in global supply chains and networks in their paper "(How) Can Blockchain Contribute to the Management of Systemic Risks in Global Supply Networks?". The authors argue that distributed ledgers like Blockchains in combination with secure multiparty computation could help to detect and manage systemic risks in large supply networks. Therefore, Blockchain could take the role of a central authority, which currently does not exist in large supply networks, and could ensure the access of data to anamnesis, diagnose or therapy systemic risks.

4.3 Risk and Crisis Management

As part of the third session on "Risk and Crisis Management", three presentations were given. The paper „Managing Systemic Risks: Opening up Public Crisis Management in Global Networks" by Moreen Heine describes design options and areas of activity based on system-theoretical foundations for collaborative and post-bureaucratic crisis management in global networks. Related work and research needs with a focus on empirical research are outlined and a research framework for public crisis management in global networks is proposed.

Increasing requirements of more volatile markets and the digital transformation of business are challenges for supply network planning and extant approaches are not capable of dealing with these challenges. Therefore, the paper "Risk-based Planning in Smart Supply Networks: The Merit of Multi-model Analytics" of Gerd J. Hahn investigates the merit of multi-model-based analytics approaches using a risk-based planning perspective along three lines: planning scope, conceptual framework, and methodological approaches.

Peter Fettke and Peter Loos describe in their paper "Prädiktives Monitoring von Geschäftsprozessen zur Beherrschung von Risiken in weltweiten Netzen auf Basis von Process Mining und Simulation" ("Predictive Monitoring of Business Processes for Controlling Systemtic Risks in Global Networks") how simulation and process mining can be used for predictive monitoring of business processes. To this end, their work proposes how artificially generated data can be used for this purpose.

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