DIESIS – Designing a Research Facility for CIP

The EU funded project DIESIS investigates the feasibility of a new facility for joint research in Critical Infrastructures and their protection, supporting particularly modelling, federated CI simulation, and analysis.

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Research on Critical Infrastructures (CI) is a complex task facing many challenges. Particularly, the investigation of dependencies between different CI requires wide domain know-how, CI data, and almost always federated CI simulation. For this task, challenges include missing interoperability of CI simulators, availability of CI data and suitable analysis tools, and establishing an effective cooperation of researchers and stakeholders. The EU funded project DIESIS addresses these challenges by proposing to establish the basis for a European modelling and simulation research facility based upon open standards to foster and support joint European-wide research on all aspects of CI with a specific focus on their protection.

Introduction

CIs that are vital for a society and its economy, such as telecom systems, energy supply systems, transport systems and others, are getting more and more complex. Dependencies emerge in various ways, due to the use of information and communication technologies, legislation, market liberalisation, and other factors. The understanding of the complex system of CI with all their dependencies and interdependencies is still immature. Yet these systems need to be protected, for instance, against cascading failures that may affect several CI sectors. Research in the area of CI Protection (CIP) therefore has to rely on using simulation systems. For simulating complex scenarios with dependencies between different sectors, typically heterogeneous federated simulations are used, but general modelling interoperability approaches or standards are missing.

The EU funded project DIESIS conducts a design study for a new research facility dedicated to joint research on Critical Infrastructures with a focus on their protection. The facility has the working title European Infrastructures Simulation and Analysis Centre (EISAC). According to the EU's ERA policy, it shall be organised as a pan-European research infrastructure. It shall offer technologies, data and services to researchers, operators of CI, makers of CI simulators, and governmental organisations and offices overseeing CI or ruling safety and security issues.

The goals of DIESIS are designing a new platform for joint research in CIP and fostering the development of new technologies for semantically interoperable federated CI simulation.

Design study

The goal of DIESIS is to perform a design study for EISAC enabling federated simulations of CI systems and supporting research on CIP. The establishment of such a distributed infrastructure in more than one country requires careful preparation. Thus, DIESIS is performing a thorough conceptual design study in order to prepare the establishment of EISAC. The work of DIESIS includes:

- Analysing in detail the requirements for EISAC coming from researchers, industrial stakeholders, decision makers and governmental organisations.

- Assessing the feasibility (scientific, technical, financial and legal) and the potential impact (scientific and technical) of EISAC.
- Developing a strategy and roadmap for the deployment of EISAC, including a business model, an organisational model of the operating entity of EISAC, a list of possible sponsors, a list of possible services to be offered, and a list of potential users and customers.

Technical work

The technical work of DIESIS comprises the following tasks: defining a set of requirements for the interoperability technology to be used for federated CI simulation, analysing available interoperability middleware, reviewing and characterising available CI simulators, developing a communication middleware and an ICT architecture for federated CI simulation, and, last but not least, identifying a process or workflow for setting up federations of CI simulators. A part of the technical concepts shall be demonstrated in a sample federation.

Communication Concepts

In order to support distributed federated simulation over various types of networks, a suitable communication middleware is required. One of the DIESIS project partners develops a quality of service enhanced communication middleware that shall work both via standard Internet (IPv4 and IPv6), high-speed networks like GÉANT [1], and private networks.

Essential communication requirements of distributed federations have been identified in order to guide the design of the communication protocols and algorithms. The most important communication requirements for large-scale federations have been identified as reliable and real-time (deadline-based) group communications. According to an evaluation of these requirements, a solution was proposed that groups all communications facilities required by the federates and the federation management system into a communication layer (CL). The CL is responsible for the delivery of federation messages under quality-of-service (QoS) criteria set by the communication requirements of the federation, also taking security and privacy aspects into account. An adaptive and reliable software architecture for the CL has been proposed that offers flexibility to support large-scale distributed federations and allows the incorporation of optimisation algorithms for group communications and security algorithms to provide communication security and privacy.

Ontologies of Critical Infrastructures

One part of the method to achieve semantic interoperability is the use of ontologies at different levels. On one hand, *Domain Ontologies* are derived from CI domain knowledge in order to formalise the conceptualisation of CI domains. They are tailor-made to the investigation at hand and depend, for instance, on the fidelity (or granularity) of the intended simulation. On the other hand, the concrete ontologies to be used are instances of *Domain Ontologies*. The instances are derived from available CI data, harnessed within the ontological conceptualisation of the domain. For each involved CI there must be at least one ontology. The simulators themselves and the federation may also require ontologies. Then, a *Federation Ontology* is realised to formalise the knowledge of cross-domain interconnections; while appropriate rules are defined to model the behaviour of those interconnections. A rule specifies the way two interconnected objects interact, allowing the propagation of effects from domain to domain. The rules are part of the implementation of the interoperability middleware. Additionally, when information needs to be exchanged between simulators in a federation that requires a transformation (e.g., transformations of units of measurements or coordinates, working ranges of parameters of infrastructure elements and so on), ontologies address the problem of the transformation factors. In general, rules and facts are stored in a knowledge-based system. Based upon a technology assessment, DIESIS has chosen to use a rule engine based on Jess for this task. A first publication describing this ontology concept has been presented at the IFIP WG 11.10 conference 2009 [2].

ICT Architecture

In the last decade, some powerful simulation tools emerged from several application areas related to CI. These tools are able to simulate technological systems (energy supply systems, telecommunication systems, railway traffic systems, …), logistic situations (military and civil operations, logistic chains, …) and common societal interrelations (e.g., economy simulations).

As a general rule, the involved simulators are closed system worlds. Typically, the design of these system worlds either disregarded the ability of coupling with other domain simulators or, in the best case, only to a very limited extent. Currently there are a number of projects that aim at coupling several stand-alone simulators in order to simulate large-scale systemic relations, like EPOCHS [3] and IRRIIS [4].

The market for simulator coupling middleware is dominated by highly proprietary solutions and differing implementations of a few standards like the High Level Architecture (HLA) for federated simulations. This situation leads to a strongly competitive acting of involved vendors. This adds to the problem of coupling simulators another – not primarily technological – dimension that makes the efforts of harmonising and coupling simulators even more difficult.

We concluded that purely generic approaches for coupling of simulators are

not feasible from current state-of-the-art. The design space of "all possible simulators" in one application area, as for instance CI, is too large for making all required ICT-mechanisms available in a generic manner.

Thus, DIESIS takes a different approach towards coupling CI simulators. Architectural core concepts considered are:

- Scenario orientation. The first step for creating a federation of CI simulators for a given investigation or research task is the description of this task by means of a network of agents and application-oriented services. This network is then gradually transformed into a technological service network that guides the realisation of the federation.
- Lateral coupling of simulators, enabling the reuse of existing coupling solutions, e.g., if the simulators to be coupled are HLA compliant. If no solution for a certain coupling exists, a new one may be created and stored in a repository (taking into account possible sensitivities of the federation). This allows for a quick start for creating federations and will lead to an increasing inventory of coupling solutions.
- Distinguishing simulator couplings based on four different types of functions (data links, function links, time links, and control links). This leads to clearer design and facilitates the reuse of the coupling solutions.

Technical demonstrator

DIESIS will realise a demonstrator for a subset of its technical concepts, including communication concepts for distributed simulation, ontologies for CI, and the outlined ICT architecture approach for achieving interoperability of the federated simulators. The demonstrator will include an electricity network simulator (SINCAL, [5]), a telecommunication network simulator (NS2, [6]), a railway simulator (OpenTrack, [7]) and a simple flood simulator. The scenario to be simulated is the disruption of CI services in a large urban region in Europe due to local flooding.

Work on organisational, legal, and economic aspects

Core aspects of the assessment of the business feasibility are the assessment of possible organisational and legal forms of the pan-European research infrastructure EISAC, a description of possible products and services, the identification of target users and customers, and the assessment of the economic feasibility.

Organisational aspects

It is clear that EISAC should have several sites in different Member States, in order to be able to provide localised services, like know-how in the specifics of national CI, but also to be able to attract national stakeholders, agencies, and ministries for the intended collaboration in CIP. The sites should cooperate closely in order to use synergies. EISAC shall have a headquarter with strong relations to the national sites.

Legal aspects

It should be mentioned here that the creation of European research infrastructures (RI) is a strong policy of the European Commission. Currently, there are about 40 active projects designing or preparing the deployment of RI. All of them have to cope with their specific organisational, legal, and economic aspects. They need to clarify the statutory seat and the legal and organisational form – aspects that are not independent from each other. In order to facilitate the foundation of pan-European research infrastructures, the European Commission has adopted a council regulation on the Community legal framework for a European Research Infrastructure Consortium (ERIC, [8]). This legal form seems most suitable for EISAC and is compatible with the proposed organisational form. The legal form of an ERIC requires EISAC to be a not-for-profit organisation.

Economic aspects

The economic assessment part of the design study includes the identification of target users and customers, the identification and description of a business model for EISAC including a detailed description of products and services and customer benefit, and, last but not least, getting support from Member States. The currently discussed portfolio of EISAC offerings has been shaped both by the DIESIS consortium and potential users and stakeholders. The latter have been involved by sending out questionnaires and by holding a public workshop for receiving feedback on the initial portfolio.

The current portfolio discussed comprises – besides technology for semantic interoperability of distributed federated simulation – several repositories, additional tools, services, and consultancy.

Repositories may contain CI data (realistic or real), models, scenarios, reusable link implementations for coupling simulators, software prototypes of simulators and tools originating from CIP research, and more.

Additional tools may comprise analysis tools, tools for logging and visualisation, tools for model and scenario management, and more.

The tool and software suites offered by EISAC could also be made available to CI operators and security offices in order to be used for private simulations in a closed company or office network.

Consultancy could be provided for various topics, including domain know-how for several CI sectors, selection of suitable simulators, setup and management of federations and more.

Conclusion and Outlook

We have presented an overview of the work of the EU project DIESIS, which

performs a design study for a new pan-European Research Infrastructure for CIP Modelling, Simulation and Analysis (MS&A). DIESIS is forming the basis for this facility, titled EISAC, by studying its technical, organisational, legal and economic feasibility.

The next steps within the duration of the DIESIS project will be the realisation of the technical demonstrator, a federated simulation of a scenario involving three CI simulators and a flood simulator. We will continue to invite potential users and stakeholders of EISAC to help shaping the services, tools and technology that EISAC shall offer. As far as the organisational, legal, and economic feasibility are concerned, DIESIS will agree on an organisational model that is compliant with a suited legal form, preferably an ERIC. An essential step towards realisation of EISAC will be the inclusion of EISAC in the research infrastructure roadmap of the European Strategy Forum on Research Infrastructures (ESFRI) [9], a body that provides support to policy makers of the European Commission. Inclusion of EISAC in the ESFRI roadmap and receiving national support by means of expressions of interest from governmental organisations in EU Member States are strategic objectives for the remaining project term. If DIESIS achieves these objectives, the realisation of EISAC might continue by entering a preparatory phase, followed by a construction phase and finally the deployment and operation of the facility.

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DIESIS Project Information

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More information can be found at the DIESIS website:

http://www.diesis-project.eu

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