CREDO

Scope

In open distributed systems, the availability and requirements of components providing services vary over time. The networks need to dynamically reconfigure communication links between components at run-time in a context-aware manner. This reconfiguration includes the (dis)connection of components, but also the adaptation and updating of both components and the network. Updates may change the computation abilities of components and the coordination abilities of the network. For safety-critical systems, updates should not compromise the reliability of services. Updates should be initiated and effectuated in a decentralized manner. No formal model of computation and communication exists today in which end-to-end system evolution can be expressed and validated. The use of formal models and validation techniques will significantly improve the confidence in dynamically reconfigurable systems, which are otherwise error-prone.

Advances

The project will develop and apply a new high-level modeling language Credo for the dynamic composition of highly reconfigurable component-based software systems, and light-weight and automated verification techniques and tools.

One of the main new contributions to language design of this project is the novel integration of a new language for modelling run-time software updates with new high-level mechanisms for the coordination and dynamic composition of software components.
The envisaged integration supports a clear separation of concerns between computation, coordination, and scheduling which provides a substantial advance in mastering the complexity of dynamically evolving software.
The modelling language investigated in Credo provides a new and challenging perspective on the formal design of software itself which includes the design of application specific schedulers.
The high-level coordination mechanisms provide a new model of 'glue code' which allows for the dynamic composition of software components.
The focus of Credo on the integration of modelling, testing, and verification of complex evolving software systems contributes to a further improvement of the application of formal methods in practice.

Positioning in global context

Modeling languages like the Unified Modeling Language (UML) are nowadays widely used in industrial practice and supported by a variety of commercial tools. An important research effort in the EU targets towards integration of formal methods in high-level modeling languages. Such an integration in general will have a profound impact on the way systems are designed and to which degree they can be trusted before actual employment. The Credo techniques are specifically tailored towards the automated compositional analysis of the behavior of dynamically reconfigurable networks of software components controlled by scheduling policies.

Contribution to standardization and interoperability issues

The Credo project will give an excellent source for modeling concepts and may be adopted by standards like the UML. Especially the component model and type-safe runtime configuration are likely candidates for adoption. We will also contribute to standardization in this area of a model for composing web services based on dynamically reconfigurable networks of mobile channels.

Target users / sectors in business and society

The results of this project will have impact on industrial applications involving complex dynamically evolving software as developed in the context of, for example, *Product Families and Service Oriented Computing* (SOC).
More in particular, potential users of the results of the Credo project are developers in the application domains of biomedical networks and incident management.

Overall benefits for business and society

The design and analysis of software is a challenging and expensive task. This is especially true for the design of software consisting of concurrent and reconfigurable components.
For example, in safety or mission critical systems up to 50% of the overall efforts have to be spent on testing. The testing framework to be developed in Credo will help to reduce these costs. The cost reduction will be achieved by systematically selecting smaller sets of test cases and by generating them automatically. In general, the integration of modeling, testing, and verification of complex evolving software systems contributes to a further improvement of the application of formal methods in practice.

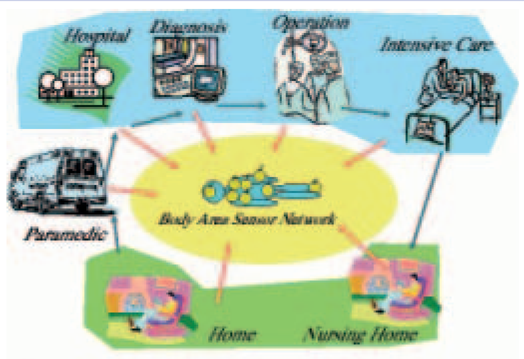
The Credo project contributes to policy development at the European as well as national and local levels by developing tools and techniques which increase the confidence in software services. The project extends the applicability of modelling and validation techniques to evolving services, thus ensuring that evolving services are trustful. Verification and validation of software is a major scientific and technical challenge of our time. These tools and techniques will contribute to Europe's leading position in verification technology and to the development of highly adaptable software services.

The case studies chosen for the project particularly target software solutions that improve the quality of life and health, in particular adaptive biomedical devices contribute to citizencentred health care systems (eHealth). The application domain of evolving services, targeted by the Credo project, is also relevant to other long-running and web-based services in, e.g., eGovernment. The adaptability targeted by Credo facilitates the interoperability of (webbased) services at the local, national and European level: services are adapted in order to interact, while they remain accessible during adaptation.

Examples of use

The ASK is an intelligent communication system which connects users who need information or skills to potential suppliers of this information or support. The specific problem of this system, addressed by our project, is to model and verify specific dynamically reconfigurable parts of the complete system using the compositional modeling and verification techniques developed in this project, in the setting of the services provided by other preexisting components.

Biomedical sensors are increasingly used to detect abnormal biological changes and monitor biological parameters in tissues and organs. Advanced hospitals are using an array of biomedical sensors for diagnostics, surgical, and post-operative phases. The outcome of this case study is a framework useful for the design of future sensor network solutions, as well as evaluation of their suitability and correctness. The framework will be designed to meet the needs towards better monitoring devices and network solutions.



Biomedical Sensor Networking Transitions in Medical Scenario

In both case studies, the outcome of the framework will be extended and scrutinized as potential commercial business cases.

Achievements

The main result obtained sofar is the development of an executable *kernel* of the Credo modelling language. This kernel integrates a textual object-oriented modelling language for *concurrent objects* and a new graphical model of *exogenous coordination* via *mobile channels*. In general, concurrent objects are well-suited as a model of distributed computation because objects do not share threads. Instead, each concurrent object has its own thread of activity which remains with the object even when external methods are invoked. The concurrent object model is based on asynchronous message passing, but does not depend on any particular network model, nor does it commit to any particular scheduling policy. Hence the object model can be combined with networks coordinating mobile channels, in which mixed and complex communication and timing models may be naturally expressed. Our notion of a mobile channel is far more general than its common interpretation and encompasses any primitive communication medium. It forms the basis for modeling a network by a novel concept of a *software circuitry*. The integration of our model of concurrent objects and mobile channels is achieved by a novel notion of reconfigurable component, which encapsulates its internal computation represented by concurrent objects and exports its *services* and external requirements through its *service interfaces*. The kernel includes a variety of automated analysis techniques ranging from simulation to testing and model-checking under specified scheduling policies.

Different aspects of this kernel language and associated analysis techniques have already been published in international conferences and journals.

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