TOWARDS ENSURING ETERNAL CONNECTABILITY

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Abstract: The aim of the CONNECT Project is to achieve universal interoperability between heterogeneous Networked Systems. For this, the non-functional properties required at each side of the connection going to be established must be fulfilled. By the inclusive term "CONNECTability" we comprehend properties belonging to all four non-functional concerns of interest for CONNECT, namely dependability, performance, security and trust. In this paper we focus on approaches for analysis and monitoring of dependability and performance of CONNECTed systems, and their combined usage.

1 INTRODUCTION

More and more modern software applications consist of systems of systems emerging from the inter-operation among independently developed Networked Systems (NSs). However, the fast pace at which technology evolves tends to form gaps among separate technological islands, and calls for the continuous development of ad hoc bridging solutions to fill those communication gaps.

Answering the challenges set out in the "ICT forever yours" initiative[1], the European FET project CONNECT (http://www.connect-forever.eu) aims at overcoming the heterogeneity barriers that prevent NSs from being eternally CONNECTed. The ambitious goal of the project is to have eternally functioning systems in spite of technology heterogeneity and evolution. This is achieved by synthesizing *on-the-fly* the CONNECTors through which NSs communicate.

On the one side, effective communication between two heterogeneous NSs speaking different languages can only be achieved by sharing a communication protocol and establishing a common agreed interpretation to the messages exchanged between the two parties. On the other, this can ensure functional compliance in the communication between NSs, but will not be sufficient to guarantee that the CONNECTed NSs will properly cooperate. To achieve effective communication, we must also provide guarantees of non-functional properties, such as reliability (e.g., the CONNECTor will ensure continued communication without interruption), security and privacy (e.g., the transactions do not disclose confidential data), trust (e.g., NSs are put in communication only with parties they trust).

In CONNECT, we coined the inclusive term "CONNECTability" to refer altogether to performance, dependability, security and trust related properties of dynamic evolving systems. As shown in Figure 1, CONNECTability is meant to include all these fours attributes. Paraphrasing dependability, which has been defined (Avizienis et al., 2004) as the ability of a system to provide its intended services in a justifiable way, this term is meant to refer to *the ability of* CONNECT *to enable the intended (i.e., dependable, efficient, secure and trustful)* CONNECT*ion between Networked Systems in a justifiable way*.

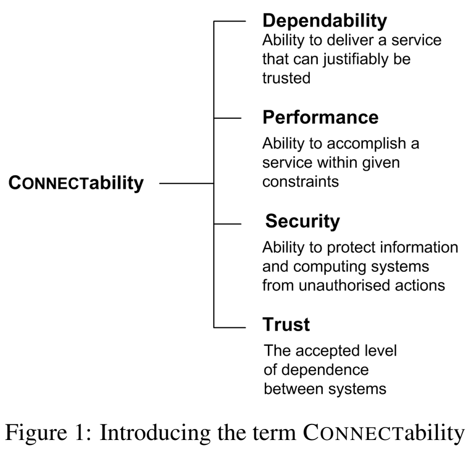

Figure 1: Introducing the term CONNECTability

[1]http://cordis.europa.eu/fp7/ict/fet-proactive/ictfy_en.html

Approaches to both off-line and run-time analysis are under development to ensure CONNECTability. In this talk, we overview the CONNECT objectives and architecture (Sect. 2), and the formal property meta-model defining CONNECTability properties in precise and machine-processable way (Sect. 3). Then (Sect. 4), we focus on the CONNECT dependability and performance Enabler and its interaction with the developed GLIMPSE monitor for the continuous runtime refinement of analysis.

2 THE CONNECT ARCHITECTURE

Figure 2 depicts schematically the CONNECT world. The components of the CONNECT architecture are called the CONNECT Enablers. Among others, the CONNECT architecture includes the following main Enablers: *Discovery*, which discovers NSs mutually interested to communicate, and retrieves information on their interfaces; *Learning*, which possibly completes the specifications of the NSs through a learning procedure; *Synthesis*, which performs the dynamic synthesis of mediating CONNECTors to enable interoperation among NSs willing to interact; *Dependability&Performance*, which uses a model-based analysis to support Synthesis in the definition of dependable CONNECTors; *Monitoring*, which continuously monitors the deployed CONNECTor to update the CONNECTor specification used by the other Enablers with run-time data. In the following, we focus on the interplay between *Dependability&Performance* and *Monitoring* Enablers. For a complete description of CONNECTability assessment approaches and related enablers we refer to (CONNECT Consortium, 2011).

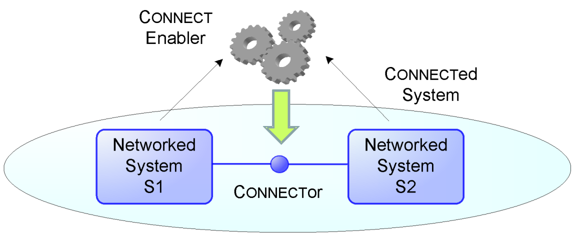

Figure 2: Overview of the CONNECT architecture

3 THE PROPERTY META-MODEL

To feed the analysis process, nonfunctional properties must be expressed in a machine-processable language. To this purpose, we have devised the CONNECT Property Meta-Model, or CPMM. CPMM defines elements and types to specify prescriptive (required) and descriptive (owned) quantitative and qualitative properties that CONNECT actors may expose or must provide.

CPMM is implemented as an eCore model and is provided with an editor. By transformation these property models will be translated into the input format for the CONNECT Enablers, e.g., the monitor, in order to be processed. A first release of CPMM is available at http://labsewiki.isti.cnr.it/labse/tools/glimpse/public/mmodelfi.

4 DEPENDABILITY AND PERFORMANCE ANALYSIS

Assessment techniques are sought in CONNECT to ensure that NSs as well as the generated CONNECTors satisfy specified levels of accomplishment for dependability and performance requirements, according to the pertinent properties specified in conformance with the CPMM meta-model.

4.1 The DePer Enabler

Before a CONNECTor is deployed, the Synthesis Enabler activates the Dependability&Performance Enabler (in the following, DEPER) to evaluate if the CONNECTed System that would be obtained satisfies the required non-functional properties. If so, the CONNECTor is deployed; otherwise, the connection cannot be established, or a new CONNECTor must be synthesized. DEPER advices the Synthesis Enabler of possible enhancements (mediator patterns) that could be applied.

DEPER performs quantitative, probabilistic dependability and performance evaluation through a model-based approach. In particular both stochastic model checking and state-based stochastic methods are supported (please refer to (Di Giandomenico et al., 2010) for details). A DEPER prototype is under development (see at http://dcl.isti.cnr.it/DEA/).

4.2 The GLIMPSE Monitor

Monitoring is a key technological enabler for context-awareness and for supporting runtime verification and online adaptation. To take into account dynamic system changes once the CONNECTor is deployed, the CONNECT Monitoring Enabler continuously observes the run-time behaviour of the CONNECTed System and provides the other Enablers with the pertinent information, in accordance with their requests.

We have developed a modular and flexible monitoring infrastructure, called GLIMPSE, which is at the hearth of the CONNECT architecture. GLIMPSE is an acronym for "Generic fLexIble Monitoring based on a Publish-Subscribe infrastructurE". It supports behavioural learning, performance analysis, reliability assessment, security and trust using a model-driven approach based on the presented CPMM meta-model. In particular, once relevant properties and metrics have been defined, they can be automatically translated to instruct the concrete monitor engine. We describe the approach in (Bertolino et al., 2011).

A prototype of GLIMPSE is available for public download at http://labse.isti.cnr.it/tools/glimpse.

4.3 Integrated Run-time Analysis

Synergic use of DEPER and GLIMPSE is pursued to allow automated refinement of dependability and performance analysis through inspection of run-time data. Precisely, feedbacks from run-time executions of the CONNECTed System as collected from GLIMPSE are used by DEPER to enhance the accuracy of model parameters adopted in the analysis performed at design time.

The interactions between DEPER and GLIMPSE Enablers start after the DEPER Enabler determines that the synthesised CONNECTor satisfies the required dependability and performance level. Specifically, after the analysis phase, if compliance with requirements is verified with the consequent deployment of the CONNECTor, DEPER instructs GLIMPSE on which are the parameters that must be kept under observation at run-time. GLIMPSE, upon receiving the request, properly sets the probes embedded in the CONNECTor.

Run-time data relative to parameters under observation are sent by GLIMPSE to DEPER. The latter continuously performs statistical analyses on the data received to verify whether the accuracy of the model parameters used in the analysis is good enough for the analysis results to be still valid, or the CONNECTor no longer satisfies the requirements and needs adjustments. In the negative case, a new analysis adopting the updates parameters values is triggered.

5 CONCLUSIONS

We have summarised the directions currently pursued in the CONNECT project for the assessment of dependability and performance related properties of dynamic evolving systems. The solution under development foresees the DEPER modular infrastructure and the flexible GLIMPSE monitor, and their interconnection to bring dependability and performance analysis to on-line stage.

On the one side, the infrastructure resulting from the interfacing of DEPER and GLIMPSE has been conceived with the highest flexibility and modularity in mind, so to allow for future further expansions, for example by including differing analysis engines. On the other, we have defined the CPMM meta-model, to make the framework *model-driven*, so to make it more general and reusable. The idea is that specific property models conforming to such meta-model can be used to automatically drive both DEPER analysis, by providing in input the requested dependability and performance metrics, and probe instrumentation of the CONNECT monitoring Enabler.

At the time of writing the project has still one year to go. For advancements on the status of the CONNECTability framework, please stay tuned at the project web site: http://connect-forever.eu/

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