An Introduction to CONNECT:

Emergent Connectors for Eternal Software Intensive Networked Systems

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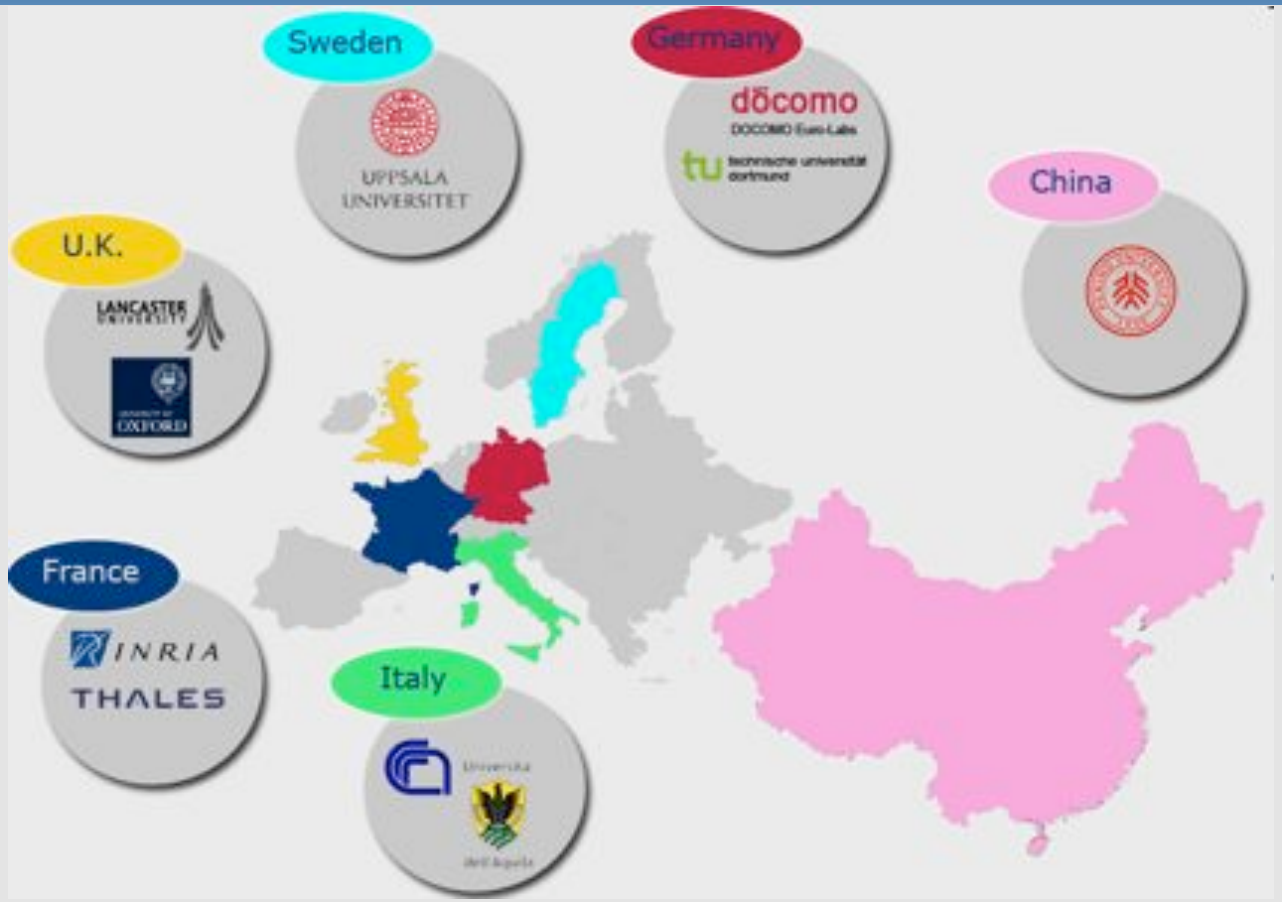
IFIP WG10.4, Ishigaki

The CONNECT Project

- **FP7 Theme:**
  - ICT-2007.8.6,
  - FET Proactive 6: ICT Forever Yours
- **Budget:**
  - Total cost: 6.5 M€ - EC contribution: 4.8 M€
- **Starting date:**
  - 02/01/2009
- **Duration:**
  - 42 months

The CONNECT Consortium



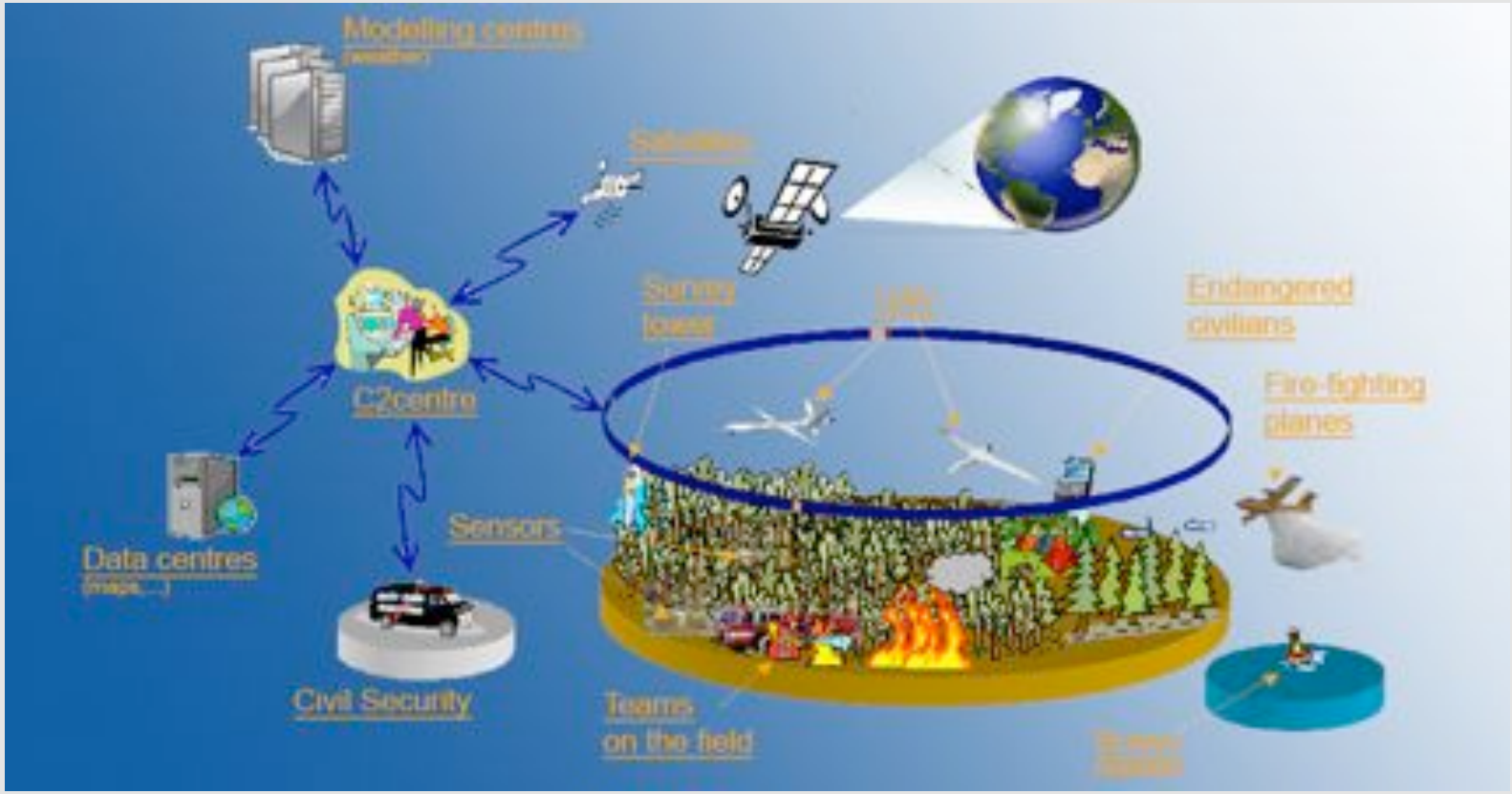
Project coordinator: Valérie Issarny, INRIA

CONNECT Research
Overcoming the Interoperability Challenge

- Pervasive computing environment that calls for the dynamic connection of devices
  - Pervasive computing devices & networks
- Increasing heterogeneity of the networked computing devices
  - From tiny-scale sensors/actuators to grid computing

A Motivating Scenario

Global Monitoring for Environment & Security



CONNECT Objective & Supporting Methodology

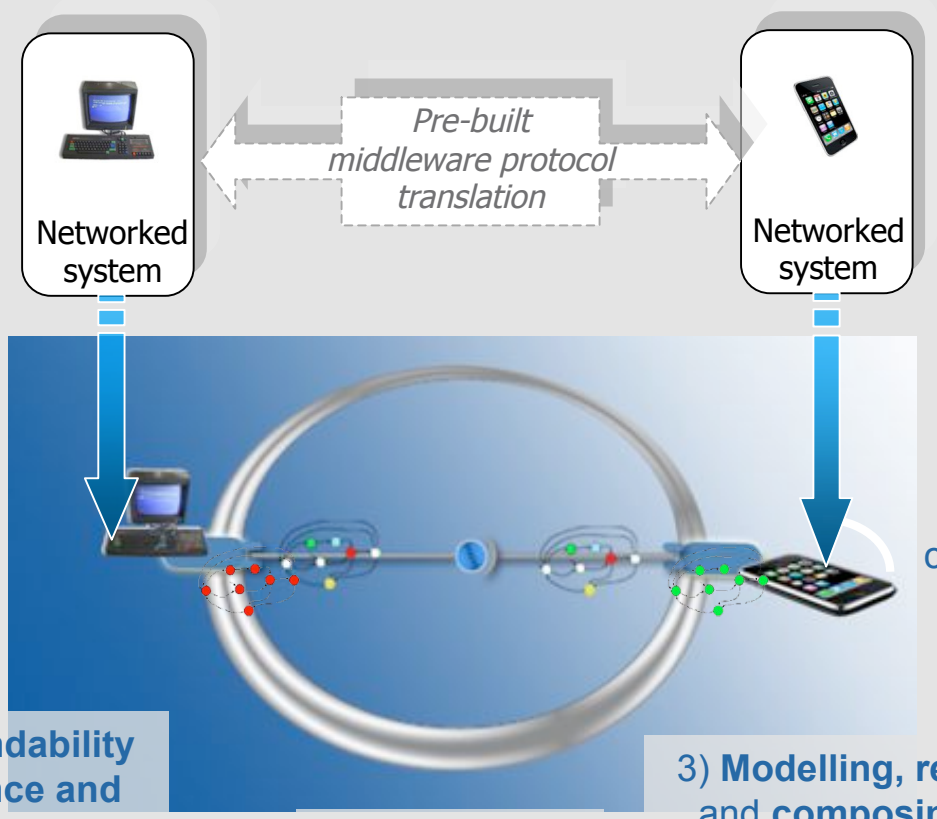
A run-time model-centric approach to eternal interoperability

From Non-CONNECTed

Pre-built connectors at syntactic level

To CONNECTed

Emergent connectors at semantic level for eternal connectivity



1) **Modelling and reasoning** about interaction functionalities

2) **Learning** connector behaviours

3) **Modelling, reasoning about**, and **composing dynamically** connector behaviours, both functional & non-functional

4) **Runtime synthesis** of connectors

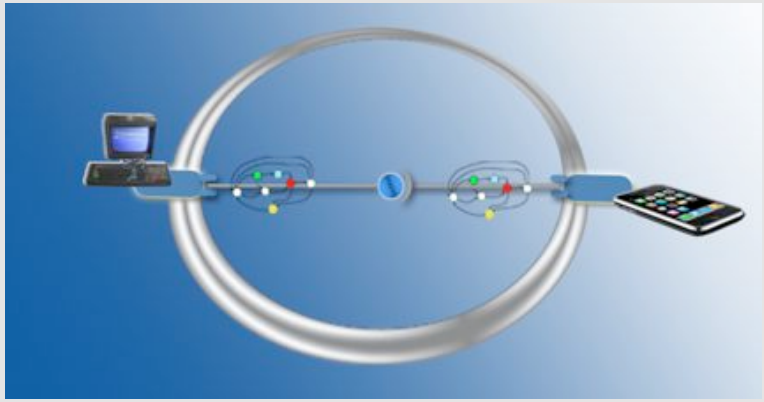
5) Dependability assurance and assessment

CONNECT Background & Innovation

A run-time model-centric approach to eternal connectivity

Get eternally CONNECTed: Emergent connectors for eternal networked systems providing run-time interoperability in highly heterogeneous environments, spanning discovery, interaction & QoS

SOTA: Proprietary middleware & pre-built domain-specific interoperability solutions for discovery and interaction protocols



Dependable interactions: On-demand dependability evaluation & automated synthesis of security connectors

SOTA: Design-time dependability & monitoring

Modelling CONNECTOR behaviours: A theory of connectors supporting automated qualitative & quantitative analyses

SOTA: Focus is on design-time usage & functional behaviour

Run-time learning: Behaviour discovery using minimal information about interfaces exposed by NS and ontology information

SOTA: Known interface & focus on functional behaviour

CONNECTOR synthesis: Performed at runtime regarding both functional & non-functional properties

SOTA: Design-time solutions focused on functional behaviour

CONNECT Contributions at a Glance

Foundation

An algebra of connectors
for automated reasoning & analysis

Methodology

Automated learning

Dynamic synthesis

Dependability assurance

Toolset

Learning tools

Model-driven synthesis tools

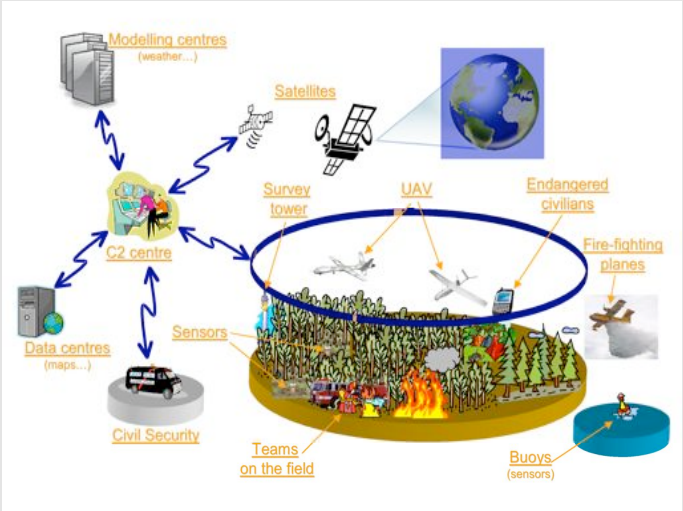
Offline/Online V&V

System architecture

CONNECT integrated architecture

OW2 Consortium

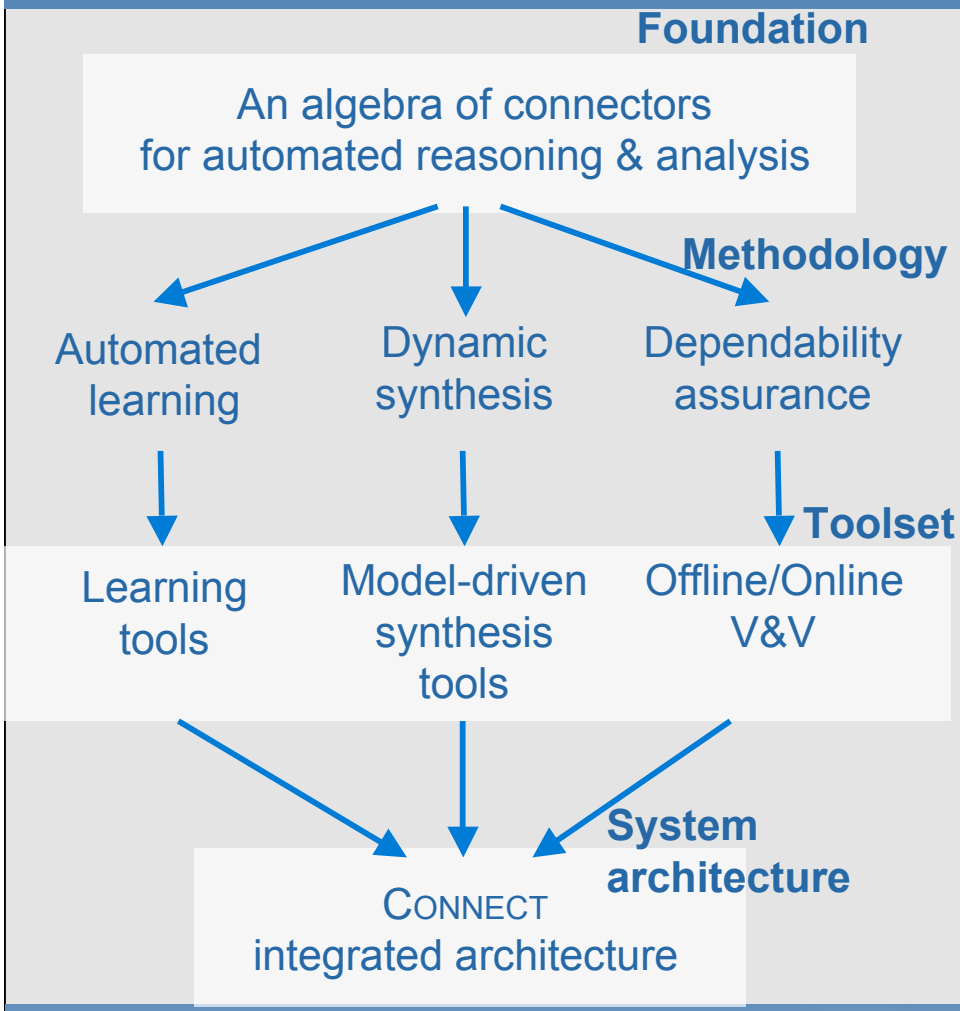
Open source approach for dissemination and exploitation: CONNECT use and evolution beyond the project lifetime



Verification & validation: Experimentation with CONNECT results in industry case studies, e.g., GMES SoS

SEVENTH FRAMEWORK PROGRAMME

In Summary: Expected Impact

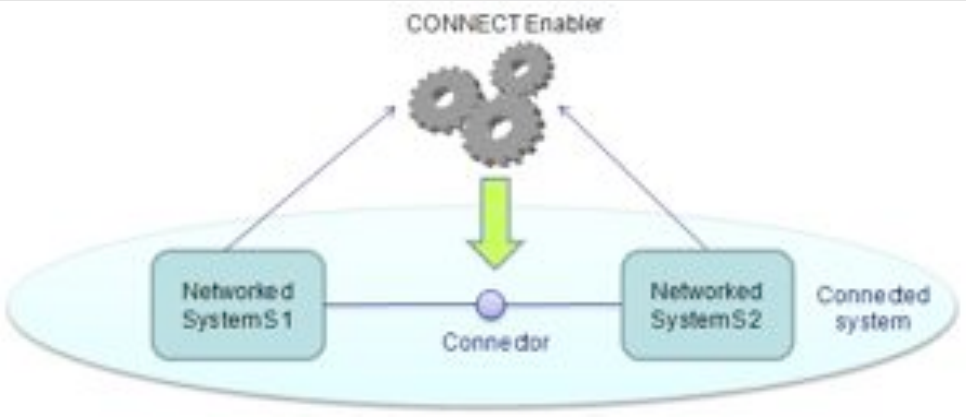


➔**Scientific**
- ➔Compositional reasoning
- ➔Automated verification
- ➔Quantitative analysis

➔**Technological**
- ➔Software evolution & management
- ➔New software lifecycle paradigms
- ➔Trustworthy networked systems

➔**Practical**
- ➔Truly pervasive computing
- ➔Supporting technology diversity
- ➔Empowering non-IT people

CONNECT Vision



- **Enablers** represent the core of CONNECT: they can accept requests from networked systems, discover new networked systems, gather / learn information on their functional and extra-functional behaviour, and synthesise a suitable Connector that allows inter-operation among networked systems willing to interact
- Synthesised **CONNECTors** are concrete, evolvable emergent system entities that allow interoperability, while not compromising the quality of software applications

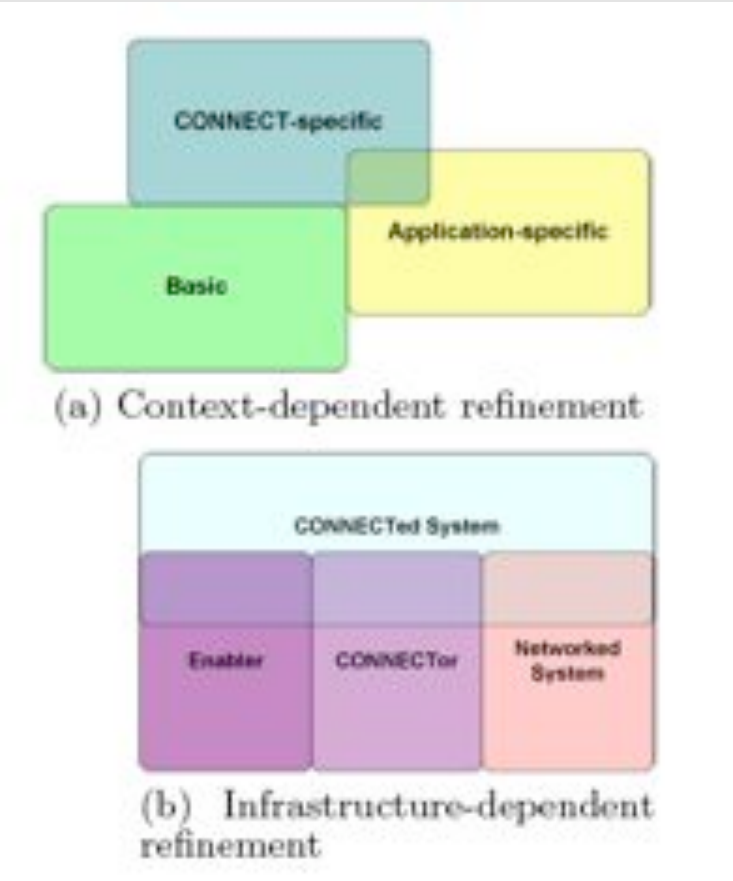
Focusing on the Dependability activities

- Wide view, including also Performance, Security & Trust
- Spanning 4 major tasks:
  - Dependability metrics for open dynamic systems
    - Including also “soft “metrics (human perspective)
    - Classical measures + refined ones along CONNECT dimensions
  - Dependability V&V in evolving, adaptive contexts
    - Stochastic model-based methods
    - Support from a *monitoring subsystem*
  - Security and privacy
    - Enforcement of security polices
  - Distributed trust management
    - A model for trust and a corresponding reputation scheme

CONNECT Metrics Framework

- Starting point: a set of generic high-level metrics
- Refinement along two main dimensions:
  - the *context-dependent* dimension
    - on the basis of the application scenario and of native architectural aspects of heterogeneous systems that populate the network.
  - the *infrastructure-dependent* dimension
    - according to structural properties of the CONNECTed world, where different entities have different roles and continuously interact and evolve in a dynamic environment.

Dimensions for Generic Metrics Refinement



Basic: metrics relevant in any Connected context

Application-specific: metrics refined according to the application domain, e.g., safety-critical,real-time, etc..

Connect-specific: metrics refined according to Connect-relevant aspects of the networked systems, such as heterogeneity and evolution capabilities.

Enabler-specific: metrics of the Enablers, which synthesise Connectors

Connector-specific: metrics of the Connector; these metrics, together with enabler-specific metrics, represent "internal" Connect metrics,

NetworkedSystem-specific: metrics of the networked systems that will use Connectors synthesised by Connect enablers

ConnectedSystem-specific: metrics of the overall Connected system

Example of CONNECT Metrics

- Generic **Reliability** Metric:

  Probability for a system to deliver a service to a certain percentage of intended destinations

- Basic,NetworkedSystem-specific
- Probability of successful reception of a message
- Application-, Connect-, ConnectedSystem-specific
- Probability to display the same message on a set of heterogeneous devices located in the same area

- Generic **Performance** Metric:
- Maximum/minimum/average expected delay incurred in communicating a message
- Basic, Connector-specific
- Time to deliver a message from n sources to m destinations
- Application-, ConnectedSystem-specific
- Time to deliver an alert message to a given percentage of people located in the stadium

Dependability analysis in CONNECT

- Useful to
  - help in guiding the on-line generation of a CONNECTor with the desired dependability/QoS accomplishment level;
  - assess dependability/QoS of emergent CONNECTor, to be used as a further criterion for the optimal selection of a CONNECTor (among several possibly available in the Connect repository);
  - assess end-to-end dependability/QoS among the networked systems
- Approaches in CONNECT
  - State-based stochastic methods
  - Stochastic model-checking
- Both complementary usage
  - best fit of the method in accordance with metrics and characteristics of the system under analysis
- and usage for cross-validation purpose are foreseen
- Both offline and online assessment

Challenges in online assessment

- Efficient definition and solution of “system” model
- Integration with monitoring for feeding model with “field” data
- Incremental approach
  - On-line usage of pre-computed analysis
    - incremental off-line exploration of a number of possible system scenarios and on-line selection of the pre-computed analysis on the basis of matching scenarios
  - On-line refinement of partially pre-computed models
    - Compositional/modular model solution
- Other approaches, such as based on Bayesian theory??