Distributed algorithms for telecommunications network and service management

A joint research with Alcatel and France-Telecom
Albert Benveniste, Eric Fabre, Stefan Haar, Claude Jard – IRISA
(Armen Aghasaryan – Alcatel, Christophe Dousson – FTR&D)
The diagnosis problem: distributed observation of the hidden state of a dynamical system

- Fault propagation – causality
- Alarm interleaving – concurrency
- Distributed processing

diagnoser

supervision

telecommunications network
The diagnosis problem: distributed state inference from alarm observation.

- Fault propagation – causality
- Alarm interleaving – concurrency
- Distributed processing
Example: **SDH/SONET optical ring nearby Paris**

**Structural model (ITU-T...)**
- physical network topology
- network elements
- connections model

**Behavioral model**

![SDH Ring Diagram](image)
A typical fault propagation scenario

St Ouen

Montrouge

Gentilly

Aubervilliers
MPLS and SDH domains - impact analysis

MPLS Domain A

MPLS Domain B

MPLS Domain C

root cause

impacted services
Model-based approach: \textit{methodology}

Structural Model (ITU-T…)
- physical network topology
- network elements
- connections model

+ Behavioral Model

\begin{center}
\textbf{Montrouge}
\end{center}
Distributed state inference from alarm observation

- asynchronous network of automata
- distributed supervisors and sensors
- distributed diagnosis: local projection of global diagnosis
Distributed state inference from alarm observation

- asynchronous network of automata
- distributed supervisors and sensors
- distributed diagnosis: local projection of global diagnosis

- Fault propagation – causality
- Alarm interleaving – concurrency
- Distributed processing
Distributed state inference from alarm observation

- asynchronous network of automata
- distributed supervisors and sensors
- distributed diagnosis: local projection of global diagnosis

A naïve algorithm:

Each supervisor marks the moves of local automaton with matching alarms and exchanges info with other supervisors

Multi-agent algorithm, tricky to program and impossible to analyse
Distributed state inference from alarm observation

a more algebraic approach

unfold \((N \times A)\)

\[ N = \parallel_i N_i, A_i : nets \]

distributed and asynchronous algorithm

Winskel’s theory of event structures

prove confluence

macros for programming
how do we get the model?
cannot be manual (huge)
new concept: self-modeling
Self-modeling, and self-deployment of the algorithm

Standards
SDH, WDM, OTN, GMPLS

Capturing architecture (network discovery)

Behavior of generic NE’s

Automatic behavioral model generation

Automatic algorithm generation & deployment
Complete functional architecture – Alcatel / Inria

ALMAP components:
- AS
- PNM
- EMP
- N-plug

Root Cause

Network topology

SLS Monitor

Generic Model

Specific Model

OSCAR
UML modelling tool

JRules, topology objects

MIB-to-SpecificModel translator

instance description

local topology files (XML)

registration, alarms / traps

SNMP Agent

MIB

Get() connectivity tables

simulated NEs

network topology

network topology files (XML)
So far…

- Concurrent models:
  - Local states
  - Local time – partially ordered by causality
- Distributed algorithms robust to asynchronous communications
- Self-modeling
- Next steps
  - Dynamic reconfiguration
  - Web services
Web services

- Today: enhancement of Web to allow for access by machines
- XML as a “universal” syntax
- Regarding communications, everything must be made explicit
- Web services are simple, stateless, remote invocations, best effort semantics – WSDL

- Tomorrow: peer-to-peer infrastructure for global computing and data exchange
- XML documents as universal extensional or intensional data AXML (S. Abiteboul)
- Peer-to-peer infrastructure of activities having states, cf. business processes of BPEL4WS
- From “best effort” semantics to a solid one!