



Towards a Unified Architecture for Resilience, Survivability and Autonomic Fault-Management for Self-Managing Networks

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■ Overview

- Introduction
- The GANA architecture for autonomic networks
- The architecture for Fault Management, Resilience & Survivability – components
- The overall framework architecture – an overview
- Summary



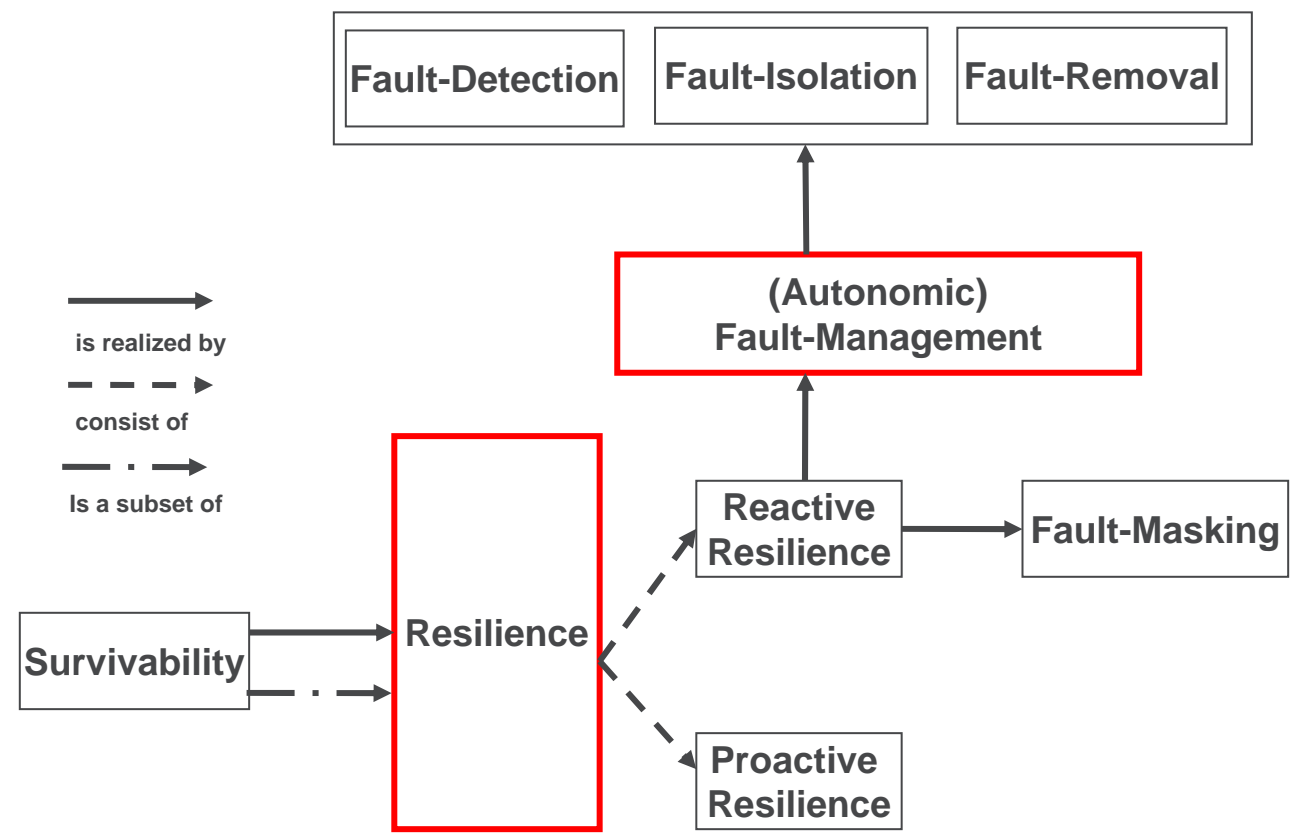
■ Introduction

- Motivation:
 - accommodate the plethora of existing intrinsic multi-layer resilient mechanisms
 - Exploit relation to **Autonomic** Fault-Management to achieve more powerful solution
 - address autonomic networks
 - Improve applications and services performance by the increased robustness of the network layer
 - Goal: propose a generic, system- and self-aware solution – the unified architectural framework
 - Exemplary situation: router failure

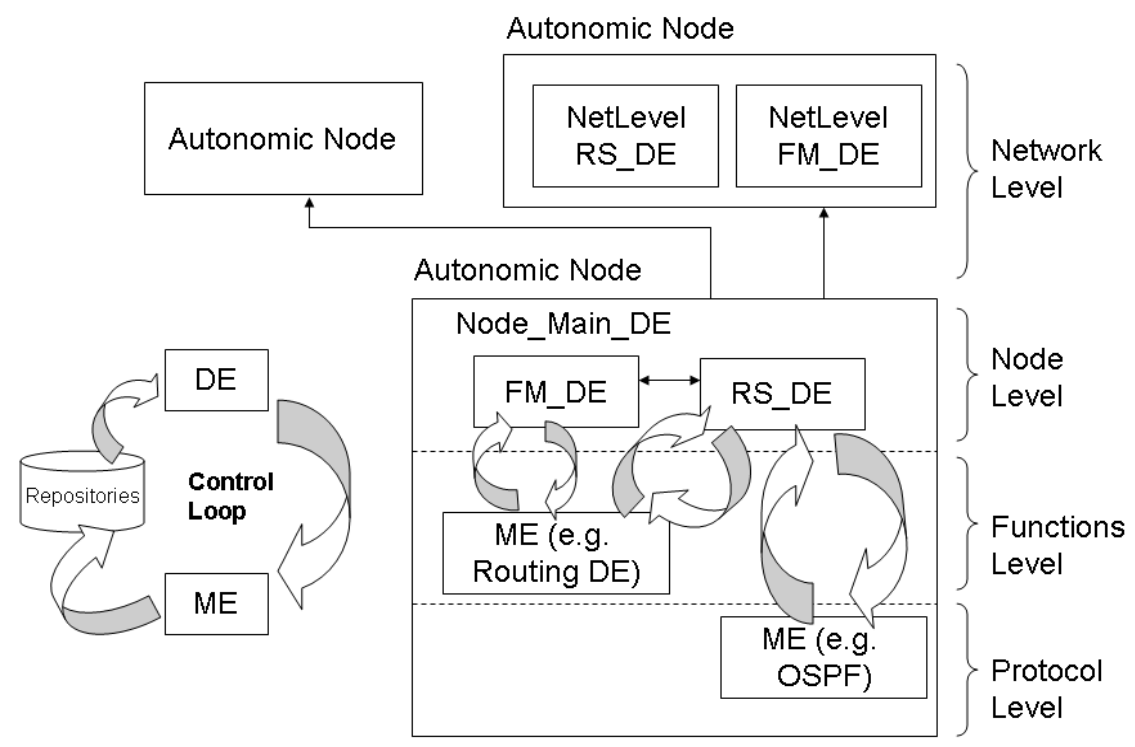


Introduction

- Relations between Resilience, Survivability and Fault-Management:



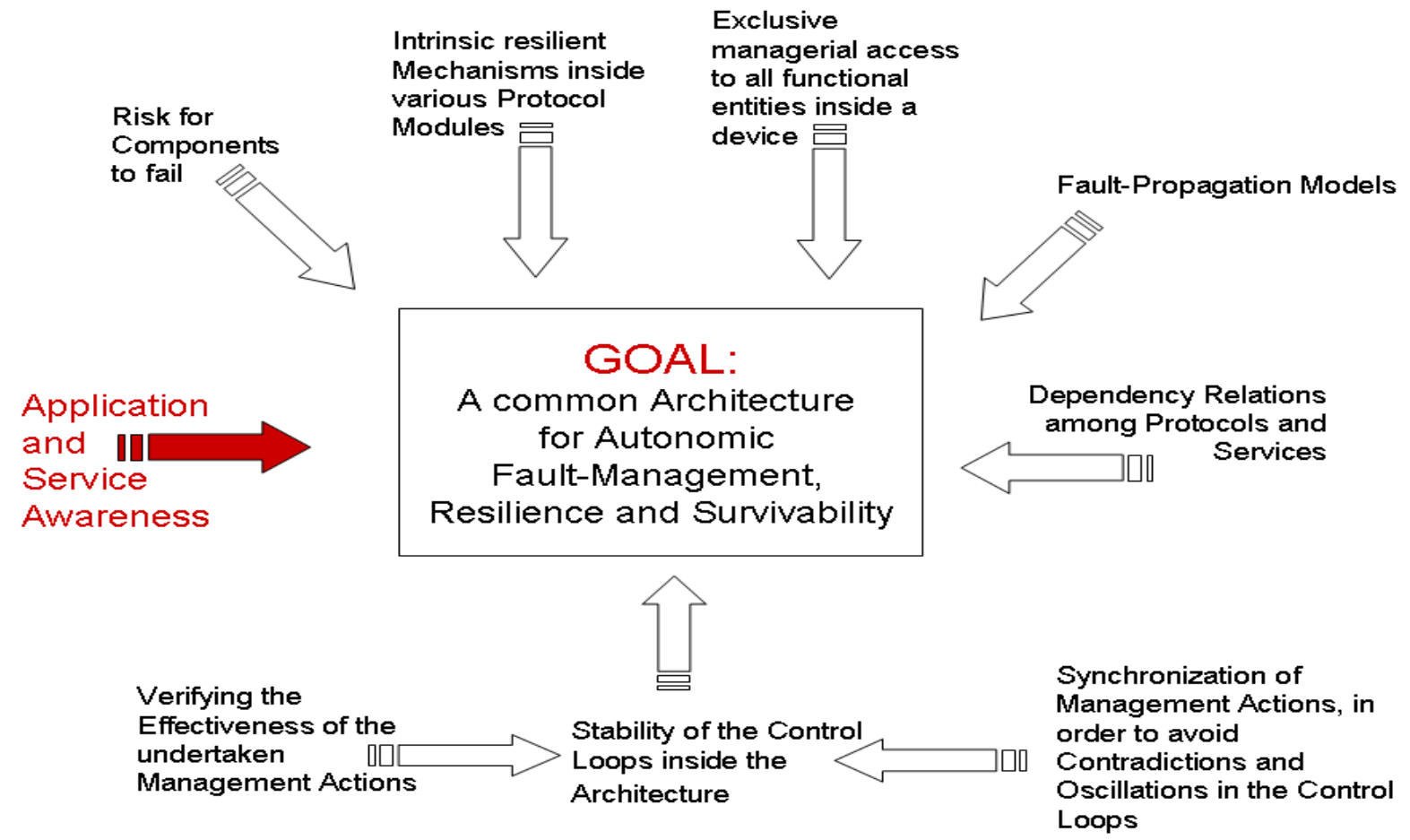
The GANA architecture - autonomy in networking



- GANA – Generic Autonomic Network Architecture – the reference model
- Designed to provide autonomy
- Components: Decision Element (DE), Managed Entity (ME)
- Concept of a control loop
- Hierarchical control loops structure (Protocol Level, Functions Level, Node Level, Network Level)



The architecture - requirements

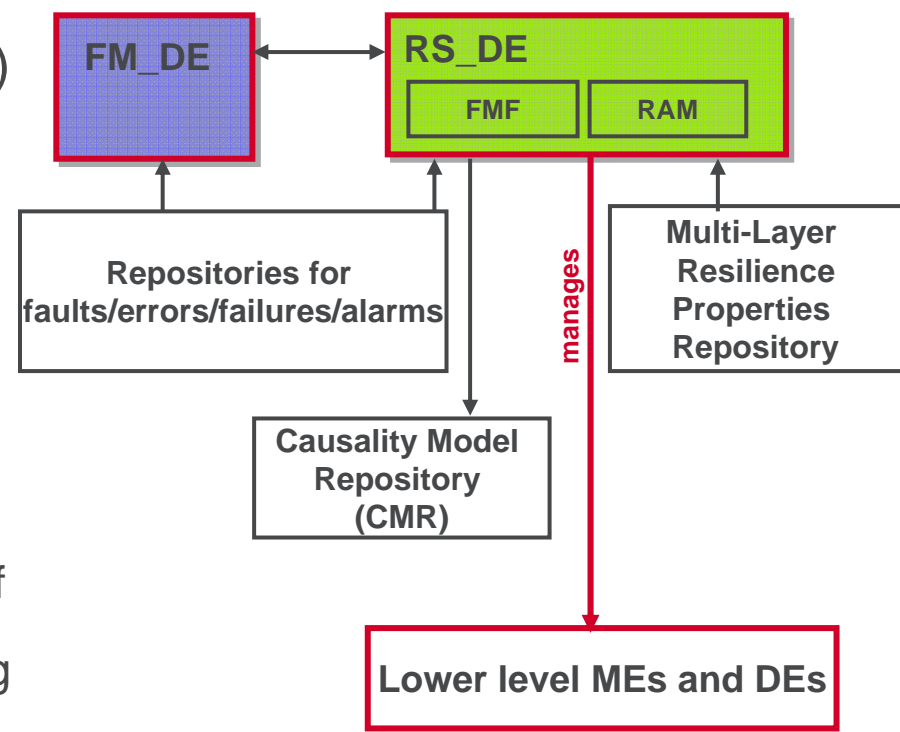



- ■ ■ The architectural components – Resilience & Survivability DE
 - Functionality:
 - Supporting generic Resilience and Survivability functions within an autonomic node
 - Node-level DE – access to all lower-level DEs and to „global”, node-intrinsic knowledge
 - RS_DE acts in a fault-tolerant manner and orchestrates resilient mechanisms of the selected node entities
 - Manages the resilient behaviour of other node entities (MEs and DEs)
 - Interactions and interoperation with FM_DE
 - Information required for operation:
 - detected fault/error/failure/alarm (node intrinsic repositories)
 - isolated faults and the Fault-Removal process (FM_DE)
 - resilient mechanisms implemented intrinsically inside the MEs in a node (*Multi-Layer Resilience Properties Repository* - MLRPR)



The architectural components – Resilience & Survivability DE

- Internal components:
 - Fault Masking Functions (FMF)* block – reactive resilience:
 - Reacts to already detected incidents
 - triggers diverse reactive fault-masking mechanisms
 - Risk Assessment Module (RAM)* – proactive resilience
 - Reacts to incidents that are likely to happen in the future
 - tries to predict the occurrence of certain incidents in the near future and is proactively steering the node entities - the node and/or network can prepare for the upcoming problems
 - dynamically improving the Causality Model



-  The architectural components – Fault Management DE
 - Functionality:
 - triggered when symptoms/anomalies indicating the presence of faults in the network are detected
 - Fault-Isolation
 - Fault-Removal
 - Information required for operation:
 - detected fault/error/failure/alarm (node intrinsic repositories)
 - causal relationships between events in the network (*Causality Model Repository* - CMR)
 - dependencies among nodes/devices, protocol modules, and services (*Dependability Models Repository* - DMR)



■ The architectural components – Fault Management DE

■ Internal components:

■ **Fault-Diagnosis/Localization/Isolation block (FDLI functions):**

- finds the root cause for the observed symptoms based on fault propagation models represented by a *Causality Model*

■ **Fault-Removal Functions block (FRF)**

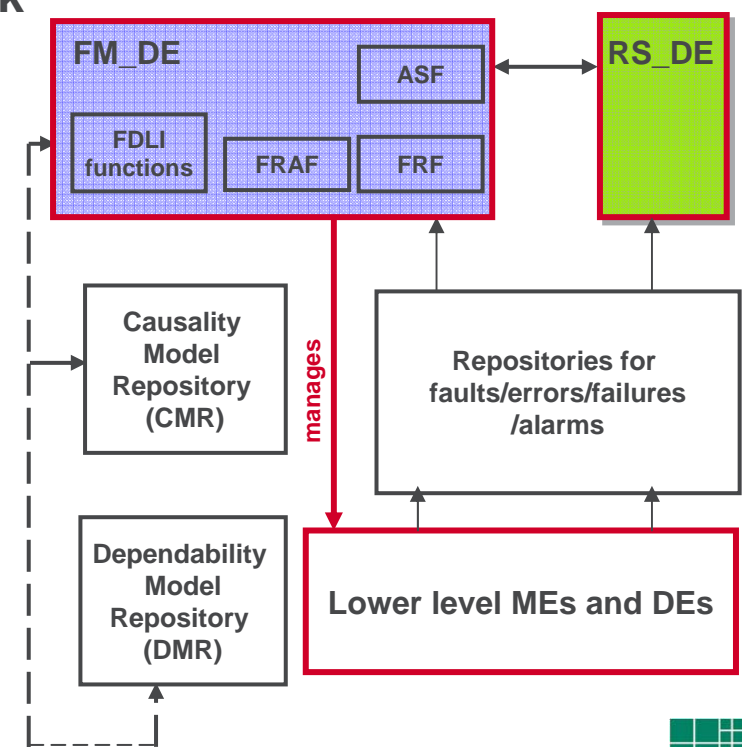
- Removes the isolated fault
- Exemplary actions: “reload a functional entity”, “reboot a node/device”, “reconfigure a functional entity” (very often **time consuming**)

■ **Fault Removal Assessment Functions (FRAF):**

- Gives the feedback information about the performance/result of the fault removal process
- Employs probing and network debugging methods or uses the risk assessment services provided by the RS_DE

■ **Action Synchronization Functions (ASF)**

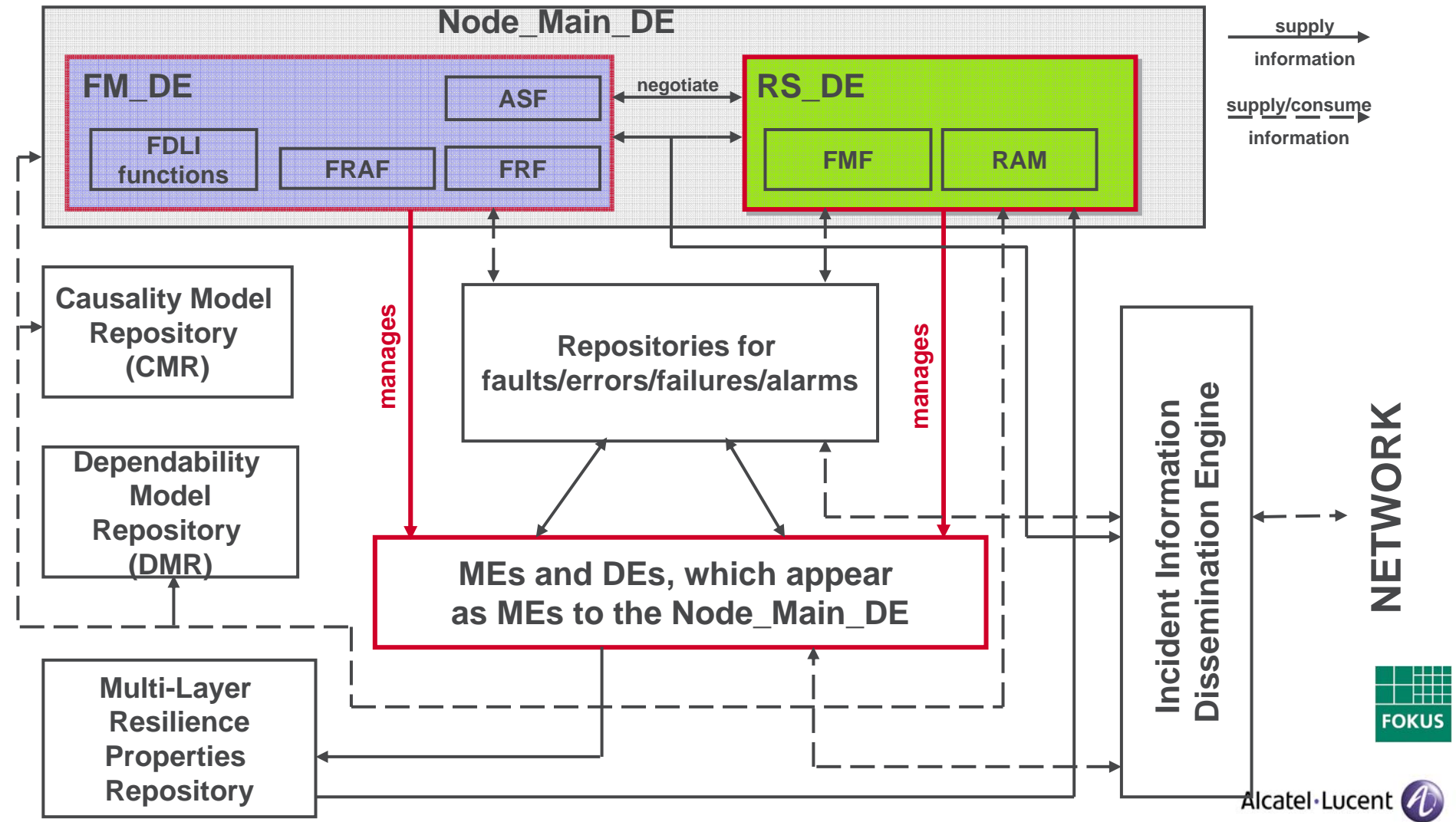
- Synchronizes the actions between FM_DE and RS_DE
- ensures stability



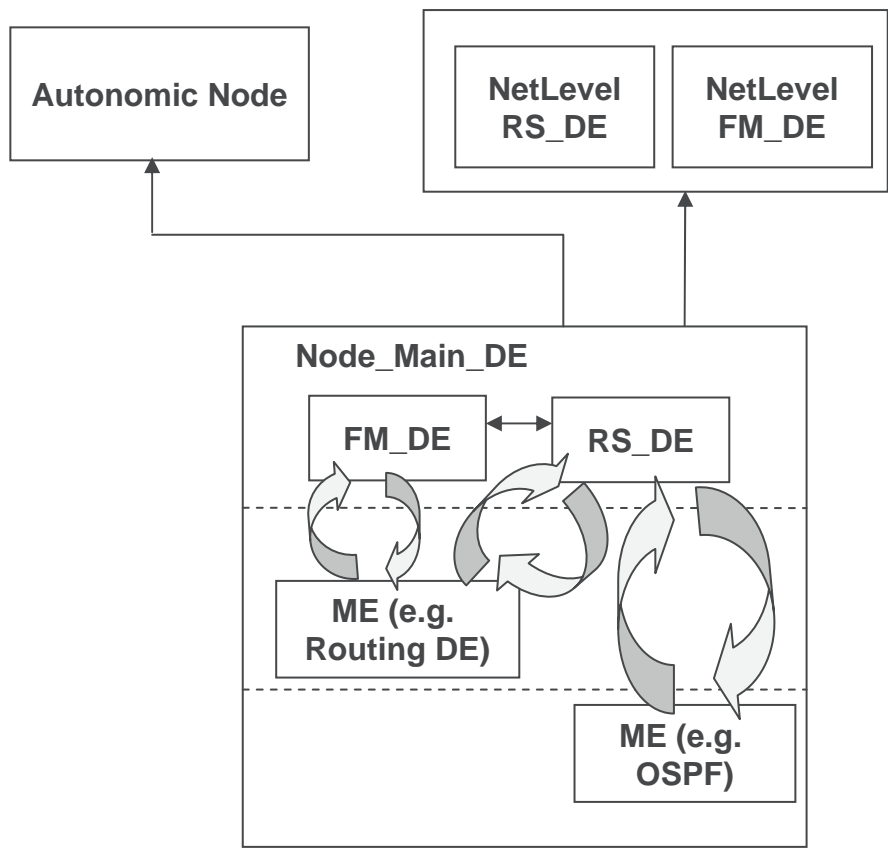
The overall framework architecture



Autonomic Node:



■ The overall framework architecture – IDE and the network level



- *Incident Information Dissemination Engine (IDE):*
 - Gives incident-related information to the other network components and services
 - accommodates the notion of *Survivability Requirements*
- Network level RS_DE and FM_DE
 - to address network level problems not resolvable in a distributed manner



■ ■ ■ Summary

- Resilience, Survivability and Fault-Management are converging as Autonomic Networks are emerging
- Architectural Frameworks are required that
 - define components addressing the converging aspects of the aforementioned functions
 - address the fundamental processes of Fault-Management, i.e. Fault-Detection, Fault-Isolation, and Fault-Removal
 - ensure the stability and effectiveness of the corresponding control loops
 - ACHIEVE SELF-MANAGEMENT W.R.T. INCIDENTS
- Future steps:
 - Implementation is ongoing – FOKUS Future Internet Lab, TARC testbed
 - Scenarios demonstration: IP black holes & duplex mismatch



- Thank you for your attention!
- Questions?



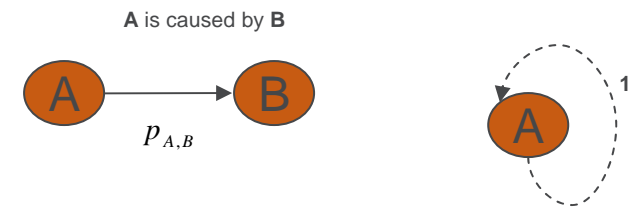
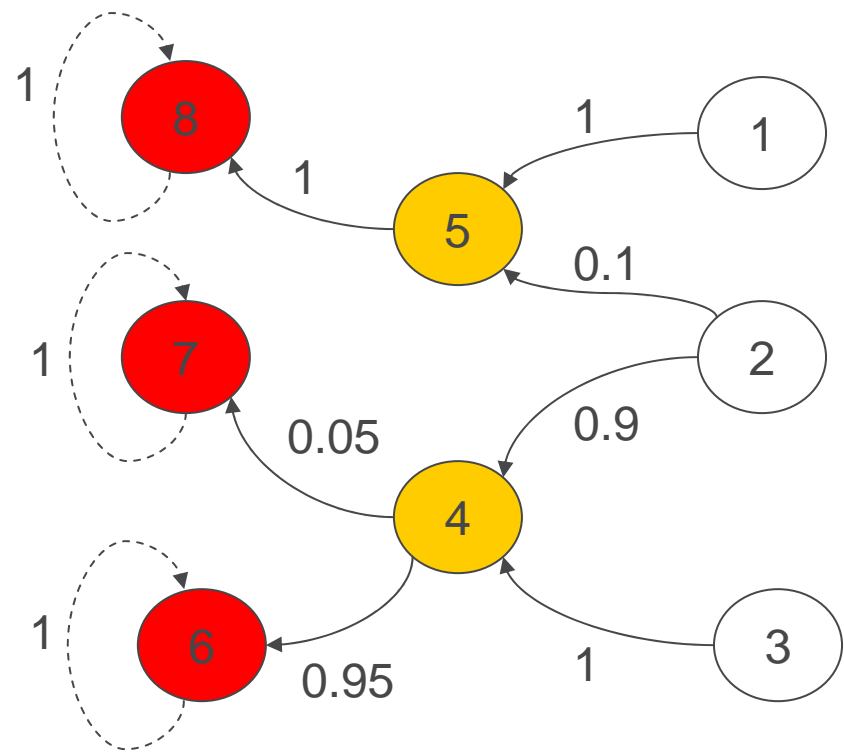


There was once a young man who, in his youth, professed his desire to become a great writer. When asked to define "great" he said, "I want to write stuff that the whole world will read, stuff that people will react to on a truly emotional level, stuff that will make them scream, cry, howl in pain and anger!"

He now works for a famous software producer, writing error messages



Fault-Isolation Functions



-
- error
- fault

$E = \{1, 2, 3, 4, 5, 6, 7, 8\}$
 $F = \{6, 7, 8\}$
 $EVF = \{1, 2, 3, 4, 5\}$



■ Action Synchronization Functions

$$NF(t_0) = \sum_{i=1}^n w_i q_i(t_0) = \langle w, Q(t_0) \rangle$$

The goal of the autonomic mechanisms is to optimize $NF(t)$ throughout the operation of the network

$$p = \arg \max_{p \in \{0,1\}^m} \sum_{i=1}^n w_i (q_i(t_0) + \sum_{j=1}^m p_j I(i, j))$$

$$\text{s.t. } D_m p \leq c$$

