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

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Overview

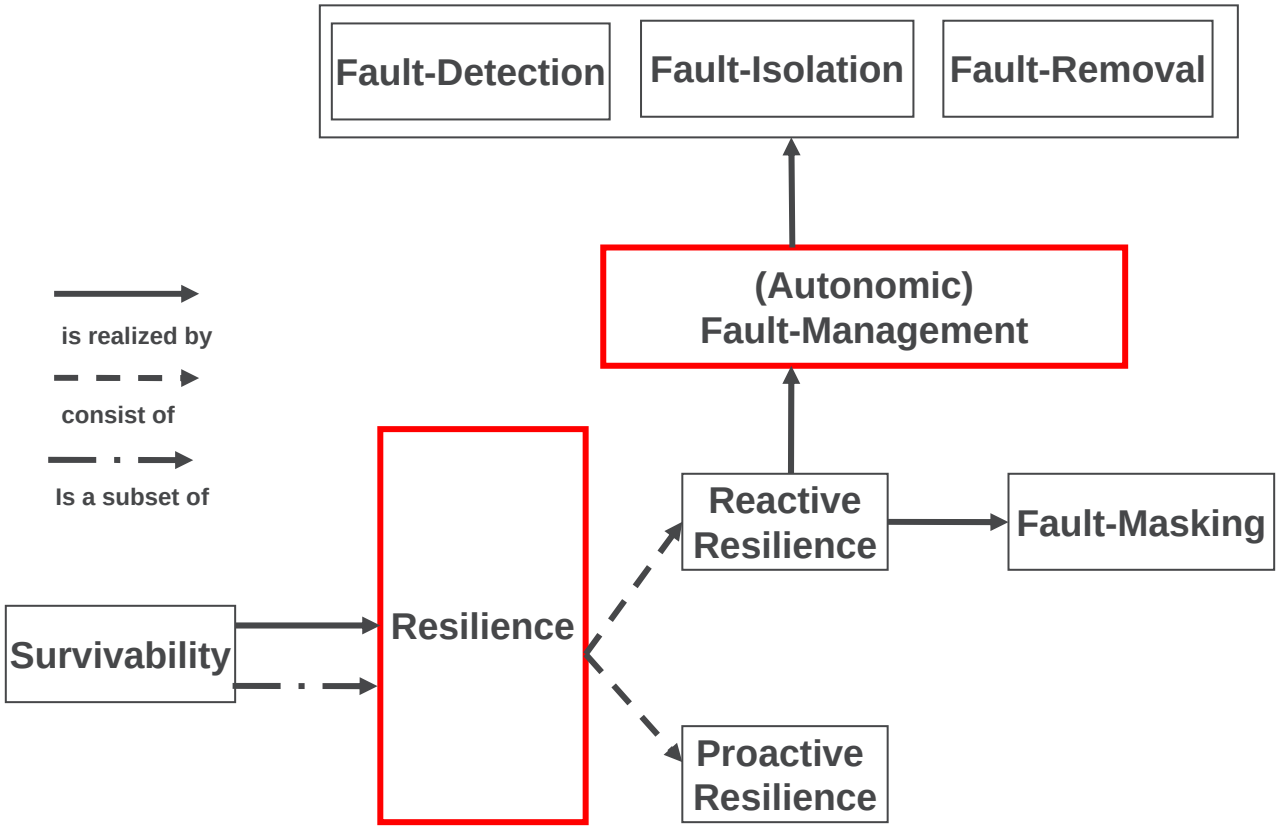
- Introduction
- The GANA architecture for autonomic networks
- The architecture for Fault Management, Resilience & Survivability – components
- The overal framework architecture – an overview
- Summary

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
  - Examplary situation: router failure

Introduction

- Relations between Resilience, Survivability and Fault-Management:



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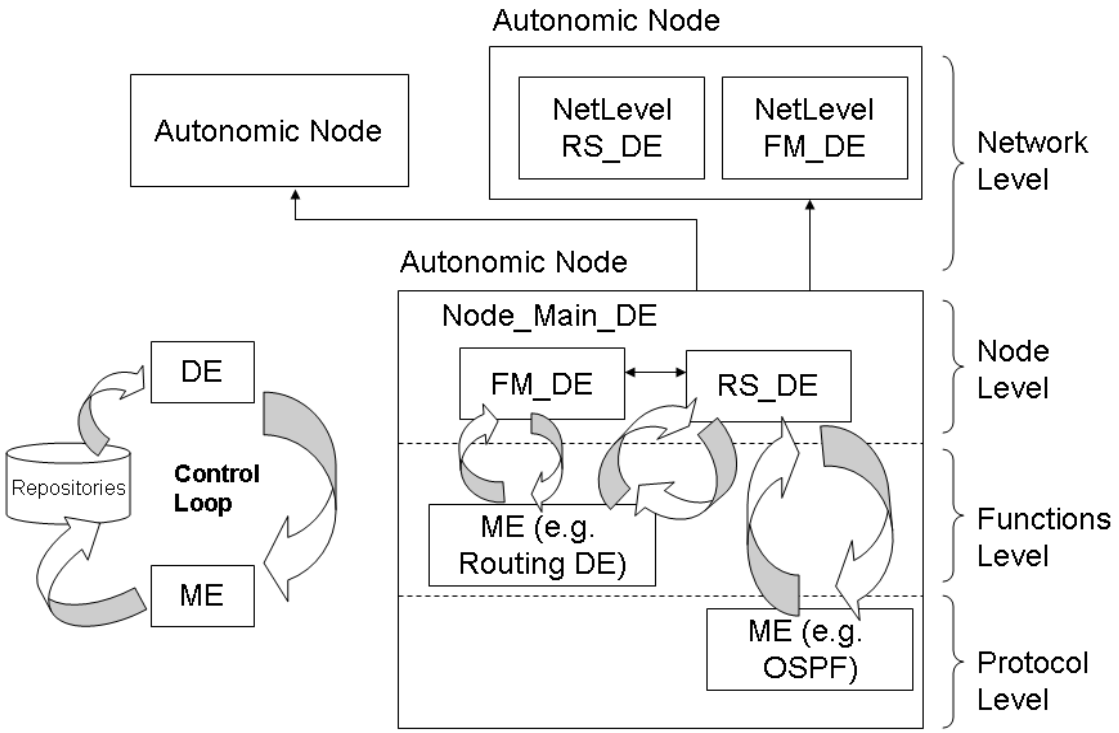
The GANA architecture - autonomicity in networking



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

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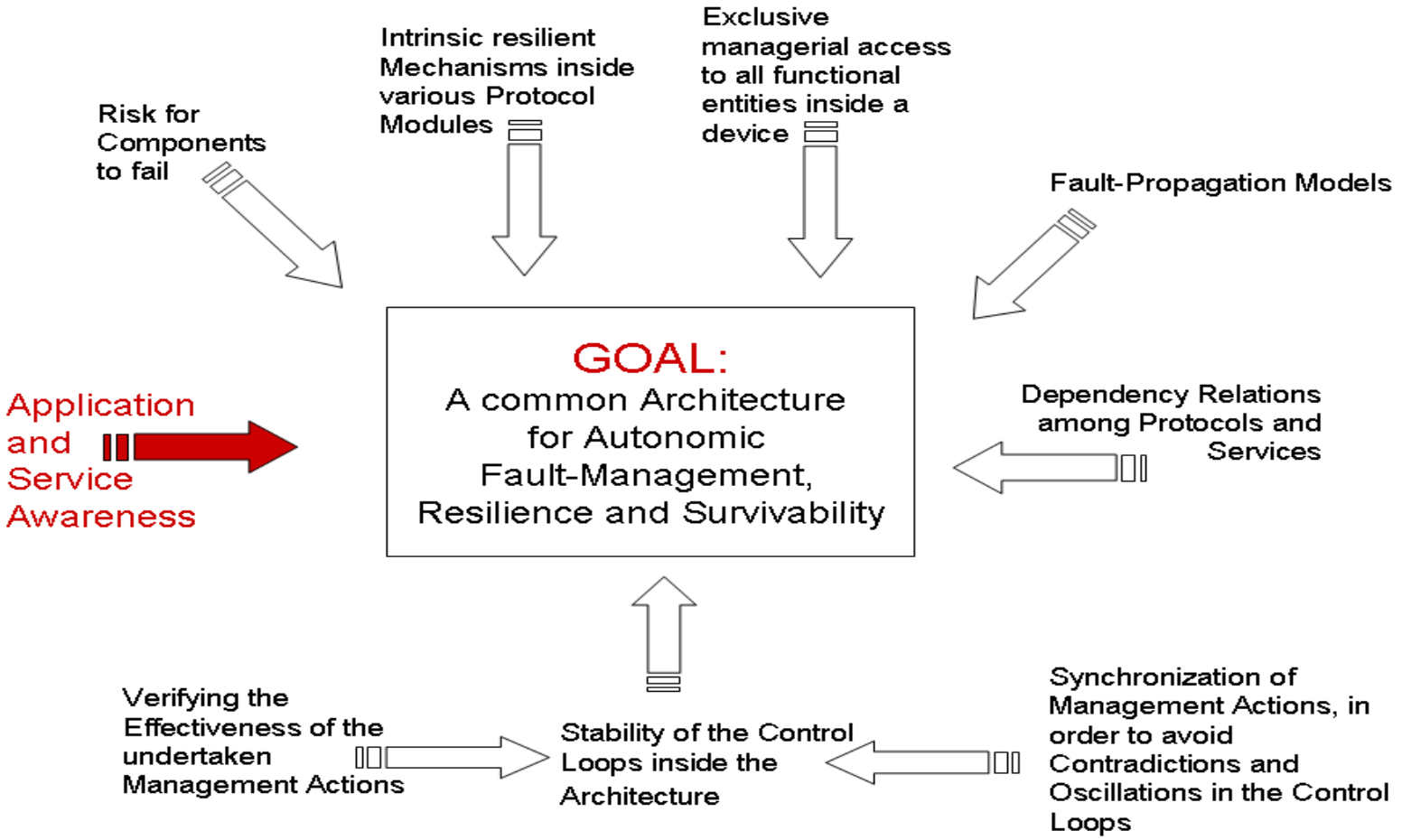
The architecture - requirements



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The architectural components – Resilience & Survivability DE

- Functionality:
  - Supporting generic Resilience and Survivability functions within an autonomic node
  - Node-level DE – access to all lover-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)

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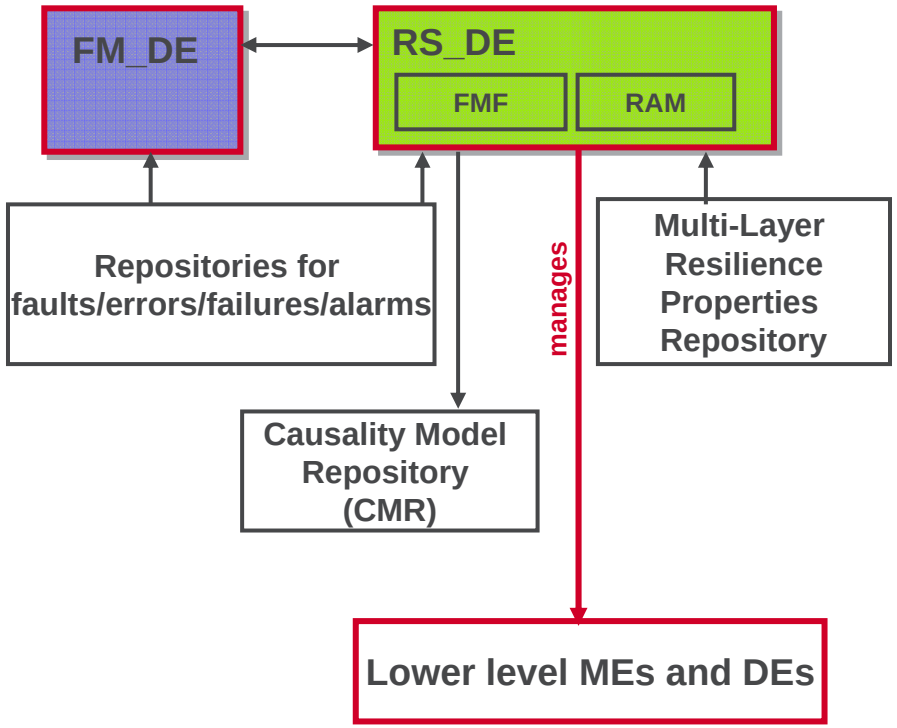
The architectural components – Resilience & Survivability DE

- 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

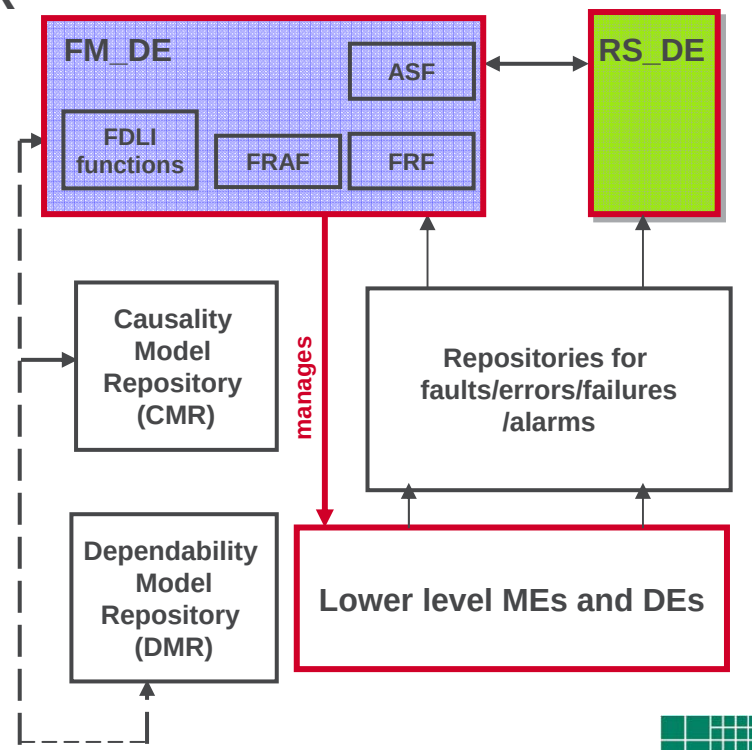


The architectural components – Fault Management DE

- 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)

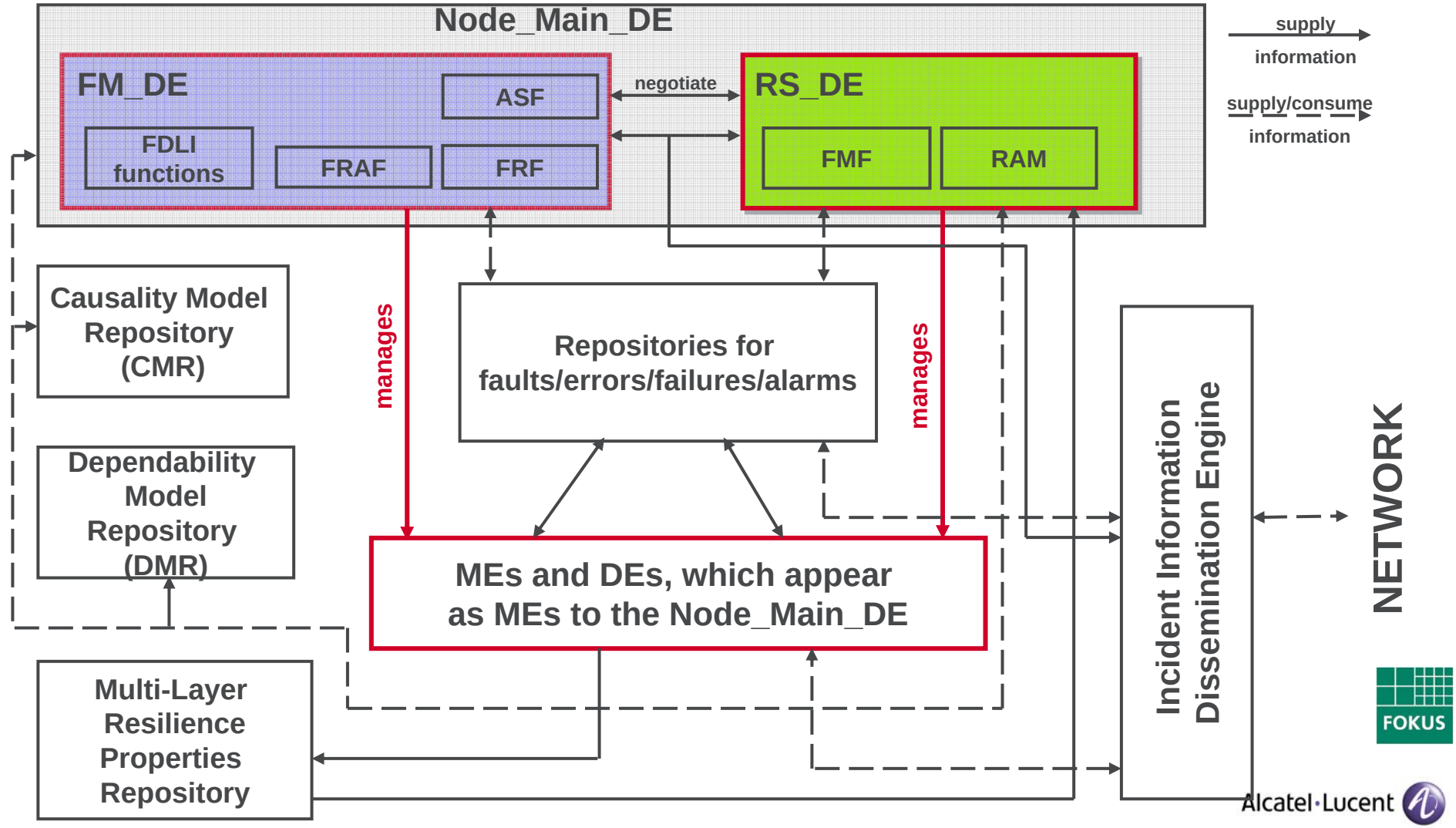
The architectural components – Fault Management DE

- 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

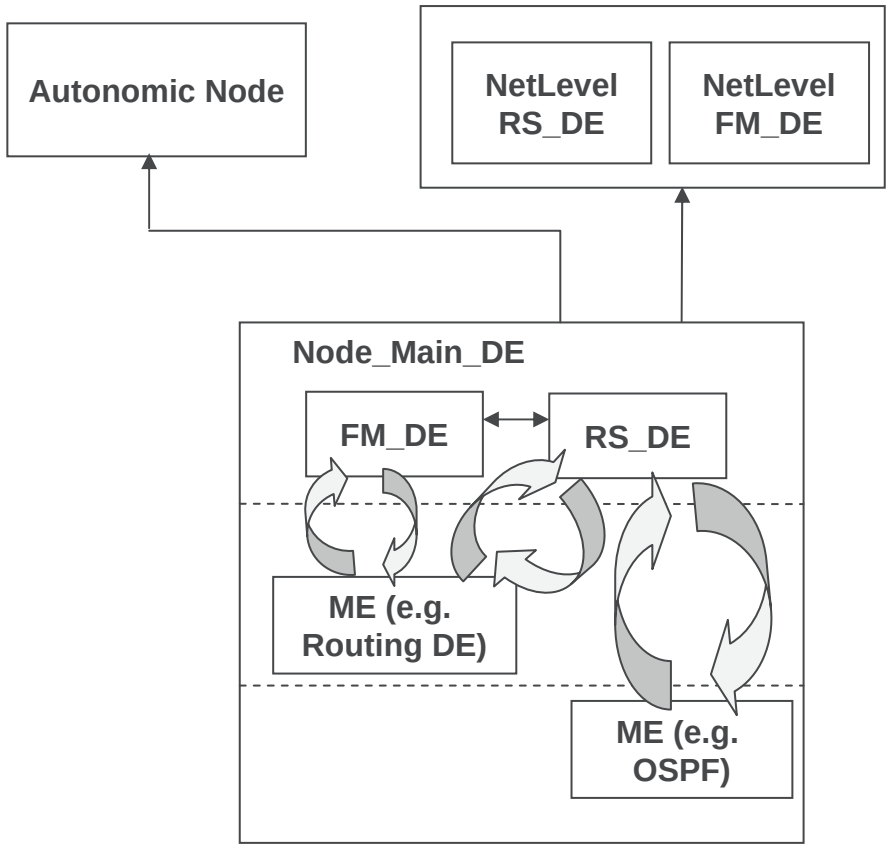


The overall framework architecture

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

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Thank you for your attention!

- Questions?

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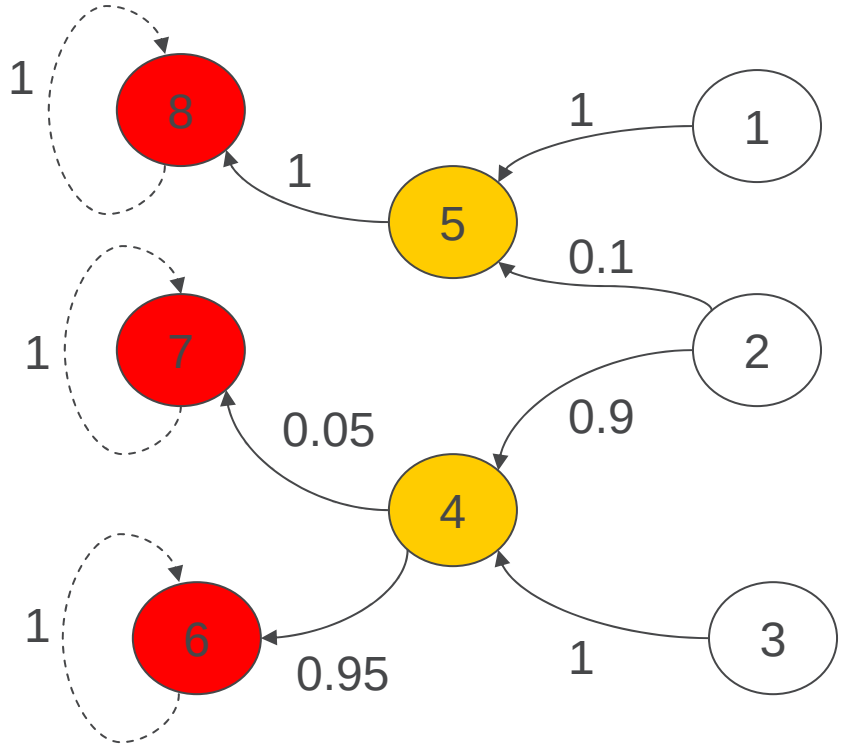
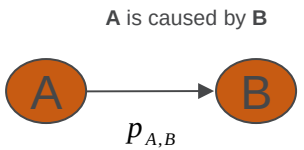
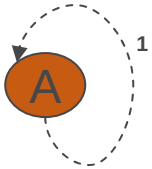
There was once a young man who, in his youth, professed his desire to become a great writer. When asked to define ”great” he said, ”I want to write stuff that the whole world will read, stuff that people will react to on a truly emotional level, stuff that will make them scream, cry, howl in pain and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

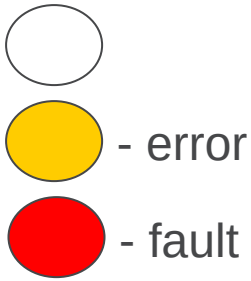
He now works for a famous software producer, writing error messages

Fault-Isolation Functions









E={1,2,3,4,5,6,7,8}

F={6,7,8}

E\F={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

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

s.t. $D_m p \leq c$