Fault Supervision for Multi Robotics Systems

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Agenda

- Introduction
- Motivations and Goals
- Theoretical Background
- State of the Art
- Research Proposal

Introduction

- Robotics becomes more common
- Variety of tasks
  - Robot arm
  - Automated guided vehicles
  - Unmanned aerial vehicles
  - Humanoid robots
    - Others…

Introduction

- Two different kinds of robots
  - Stationary robots
  - Mobile robots

Introduction

- Mobile robotics is the research area that handles the control of autonomous vehicle or semi-autonomous vehicle.
- Currently, there are few commercial applications of mobile service robots

- Robotics has been evolving fast in terms of new functionalities and becoming affordable

Introduction

- Mobile robots have not yet made much impact upon industrial and domestic applications, mainly due to the lack of dependability, robustness, reliability and flexibility in real environments.

Introduction

- One cost-effective way to provide effectiveness and robustness to robotic system is to use multi-robots instead of a single robot
- MRS have some advantages over single-robots systems
  - *Increased of speed*
  - *Task completion through parallelism*
  - *Increased of robustness and reliability*

Introduction

Classification of MRS

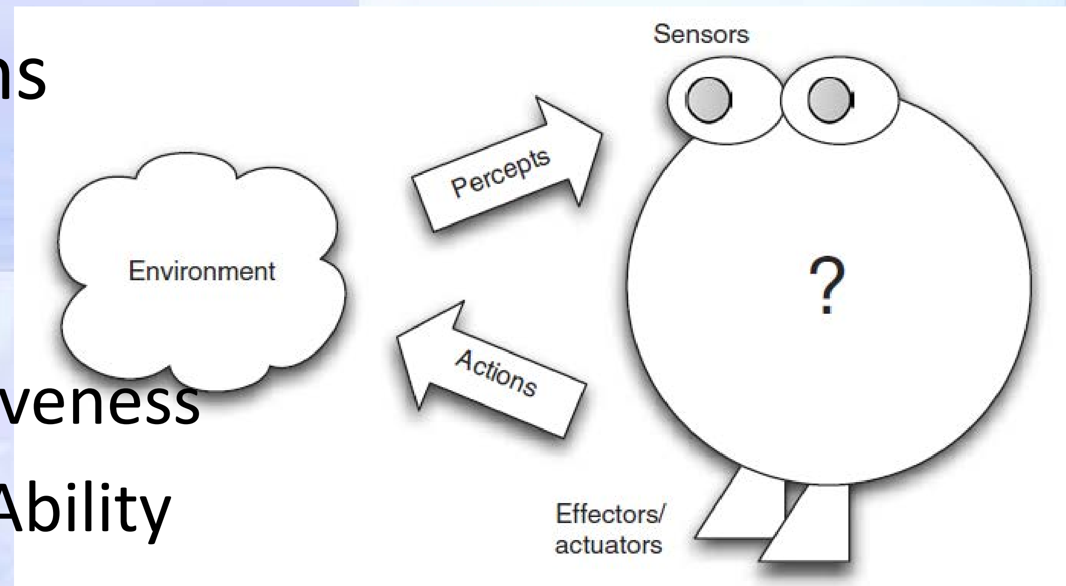
- Homogeneous
  - All members of the team have the same specification
- Heterogeneous
  - Different kind of robots in the same team

Motivations and Goals

- Mobile robotics will become commonplace, cost-effective and dependable
- The *goal of this work* is to provide monitor faults at a team of heterogeneous robotic agents
- More dependable, More applications

Theoretical Background

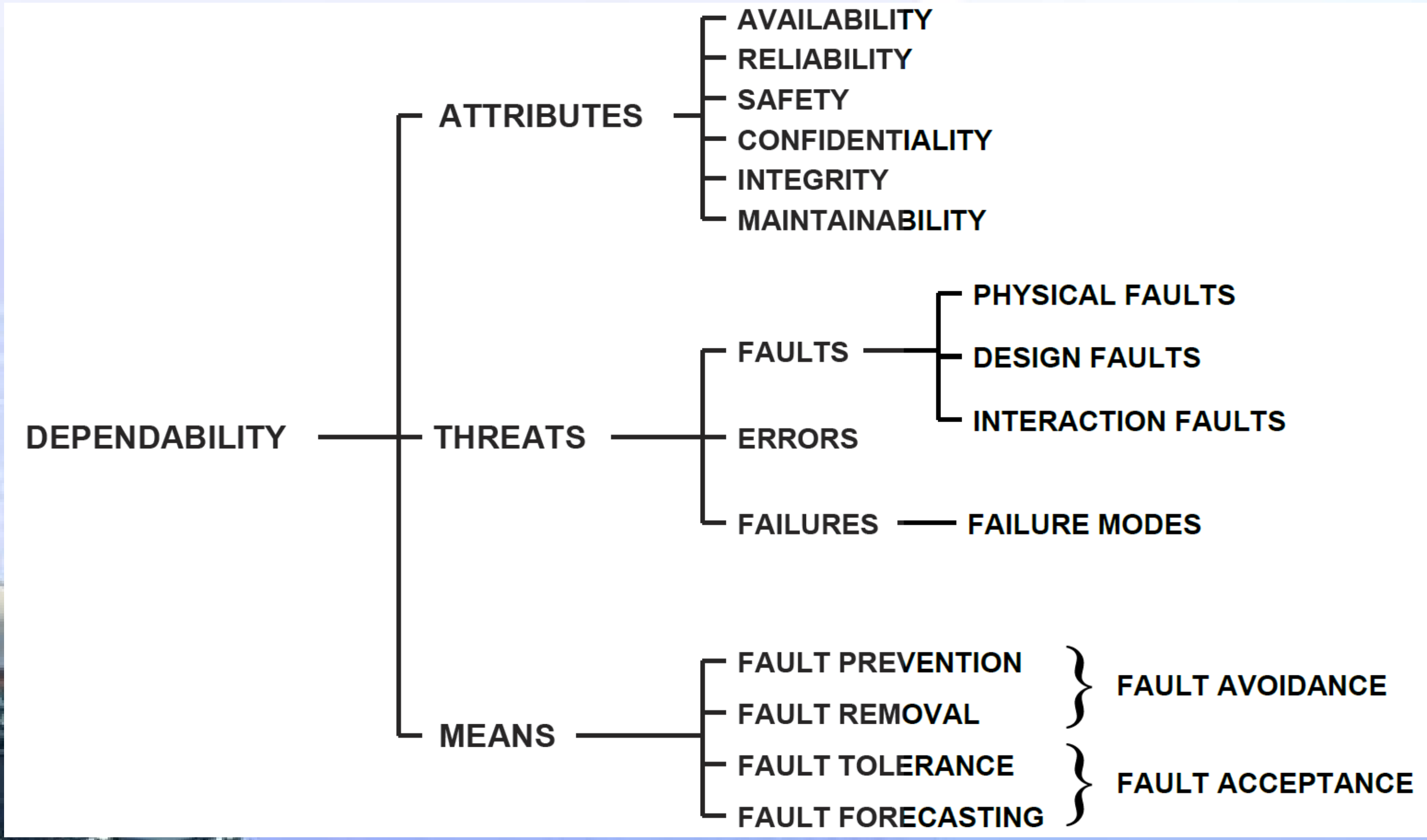
- Autonomous Agents
- Characteristics of Agents
- Multi-Agent Systems
  - Autonomy
  - Pro-activeness
    - Re-activeness
    - Social Ability



Theoretical Background

- The ***dependability*** of a computing system is its ability to deliver service that can be trusted;
- ***Correct service*** is delivered when the service implements the system *function*, that is what the system is intended to do.

Figure 1: Dependability tree



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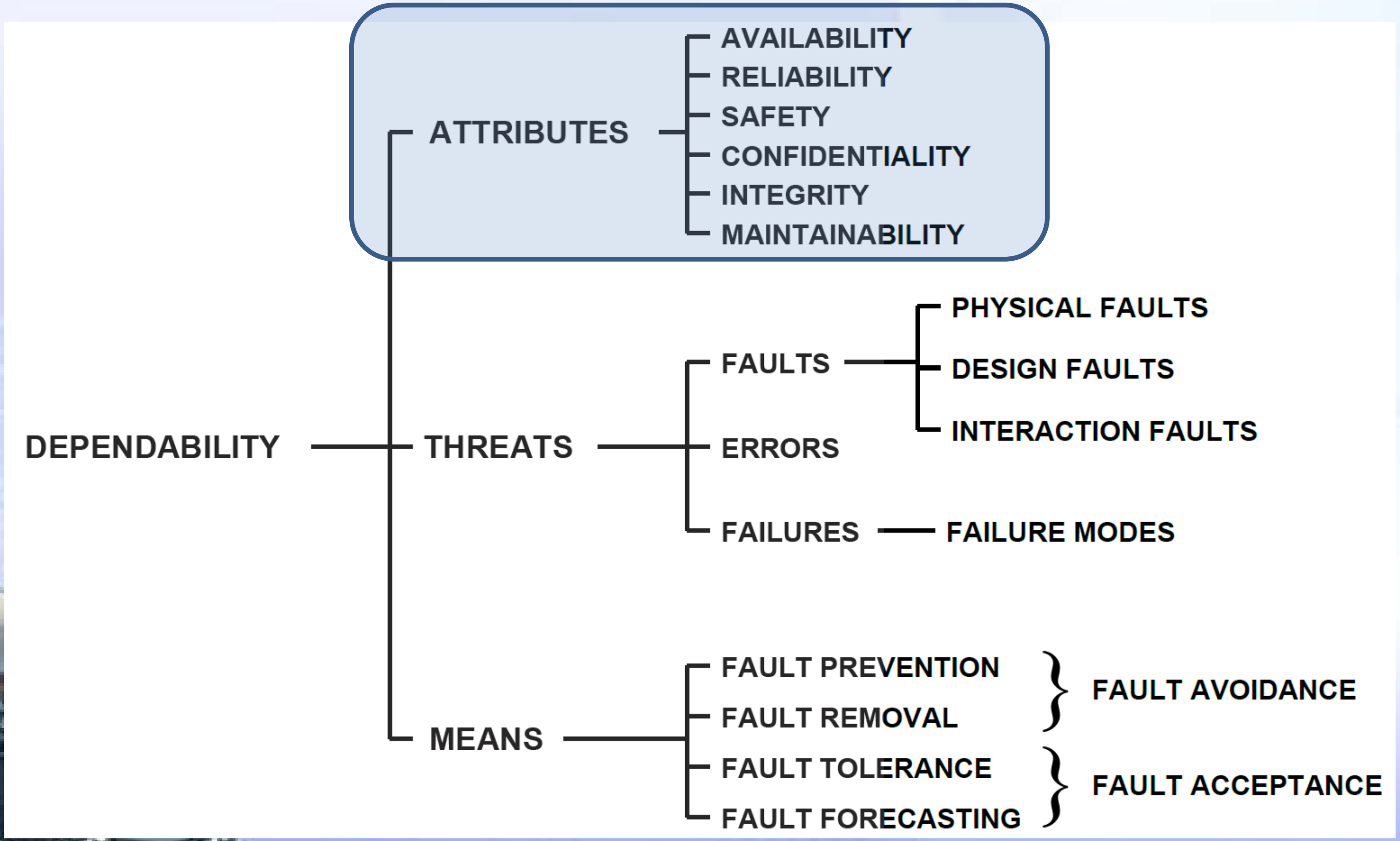


Basic concepts

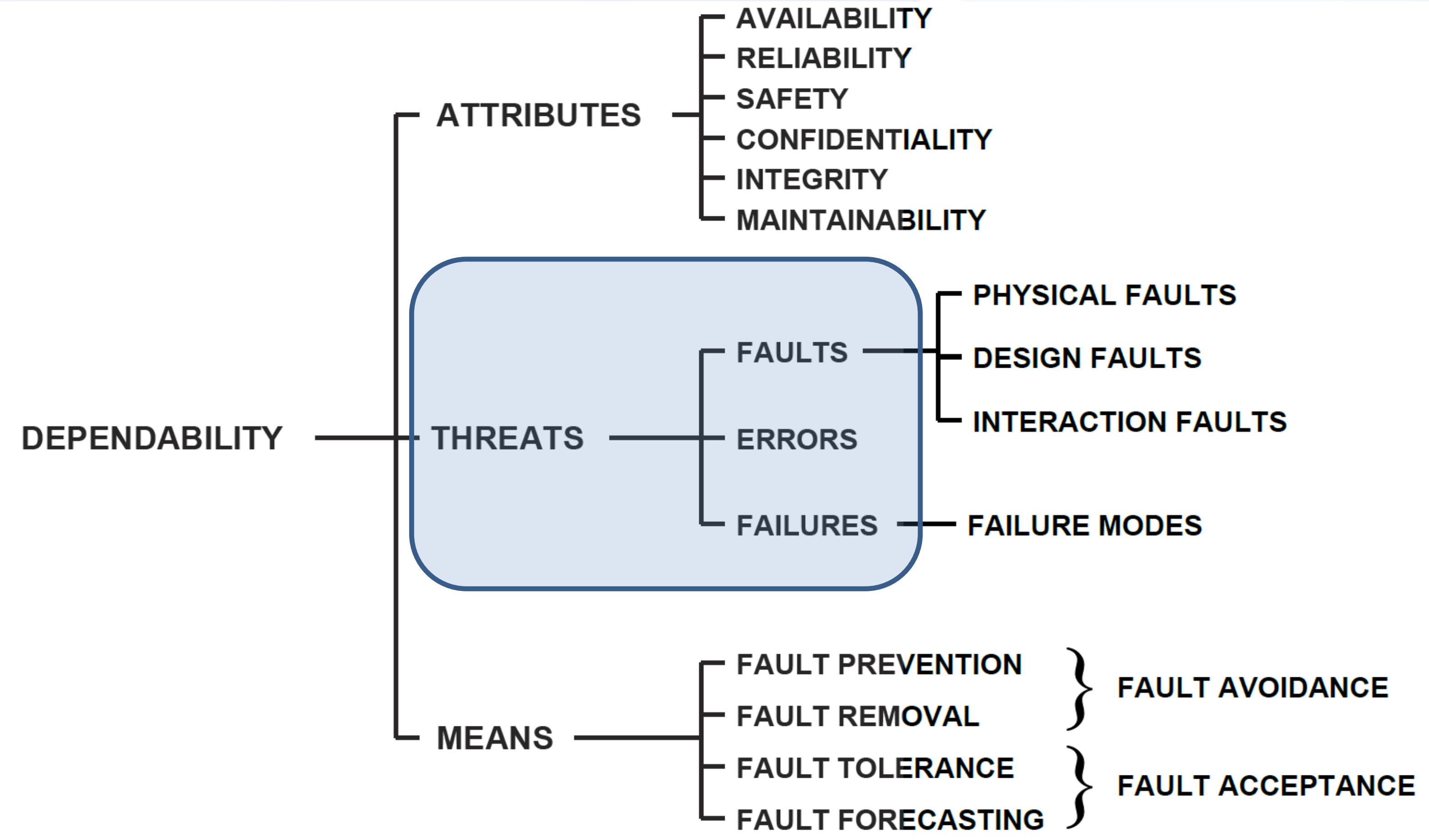
- ***Availability:*** the deliverance of correct service at a given time/period of time,
- ***Reliability***: the continuous deliverance of correct service for a period of time,

- ***Safety***: the absence of catastrophic consequences on the users and the environment,

Basic concepts

- ***Confidentiality***: the absence of unauthorized disclosure of information,
- ***Integrity***: the absence of improper system state alterations,
- ***Maintainability***: the ability to do repairs and modifications

Figure 1: Dependability tree



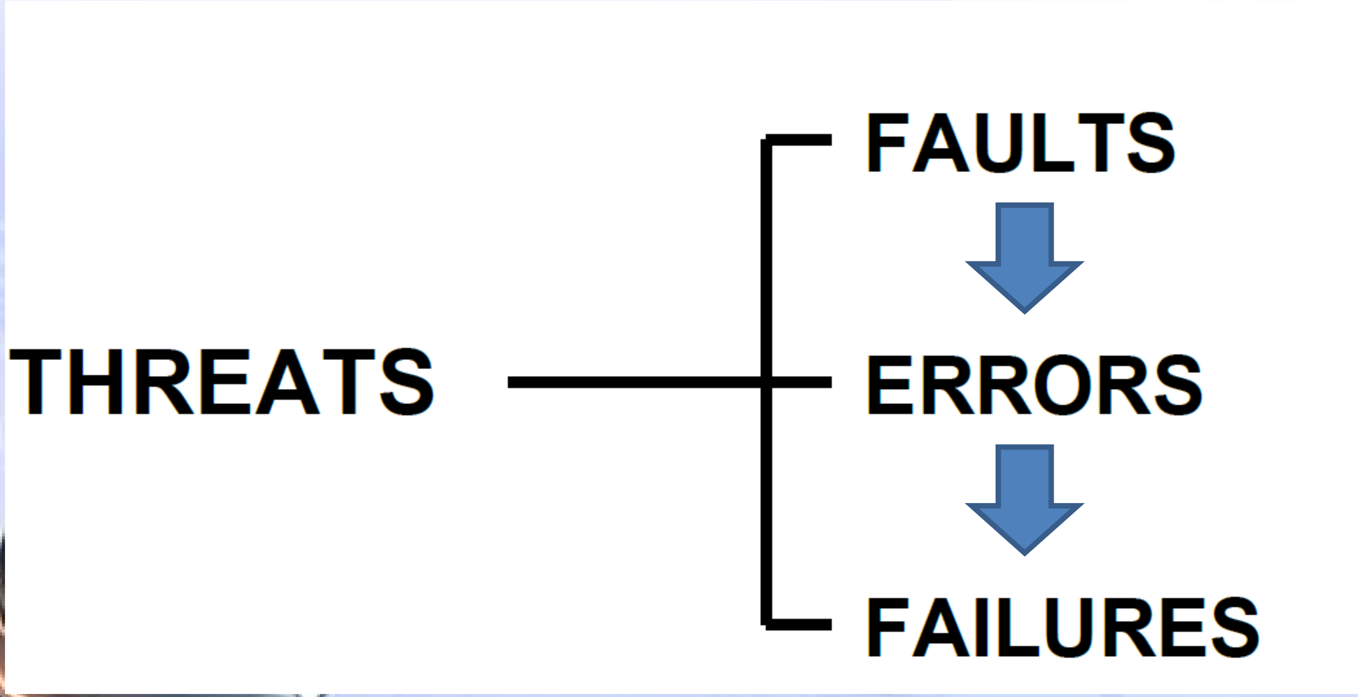
Basic concepts

- The ***threats*** to a system's dependability consist of **failures, errors and faults**
- A system ***failure*** is an event that occurs when the delivered service deviates from *correct service*.

- An ***error*** is that part of the system state that can cause a subsequent failure.

Basic concepts

- A **fault** is the cause of an error.



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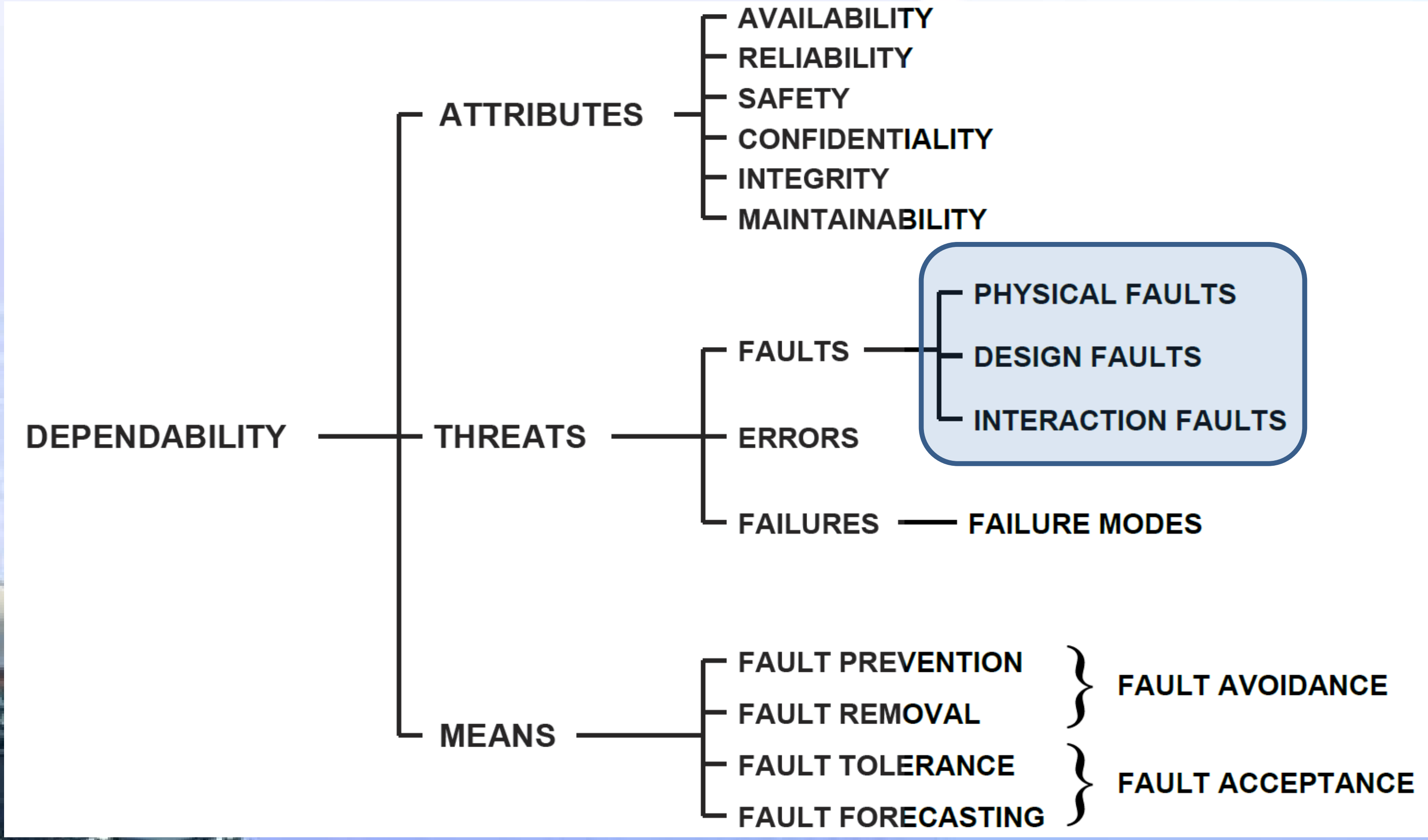
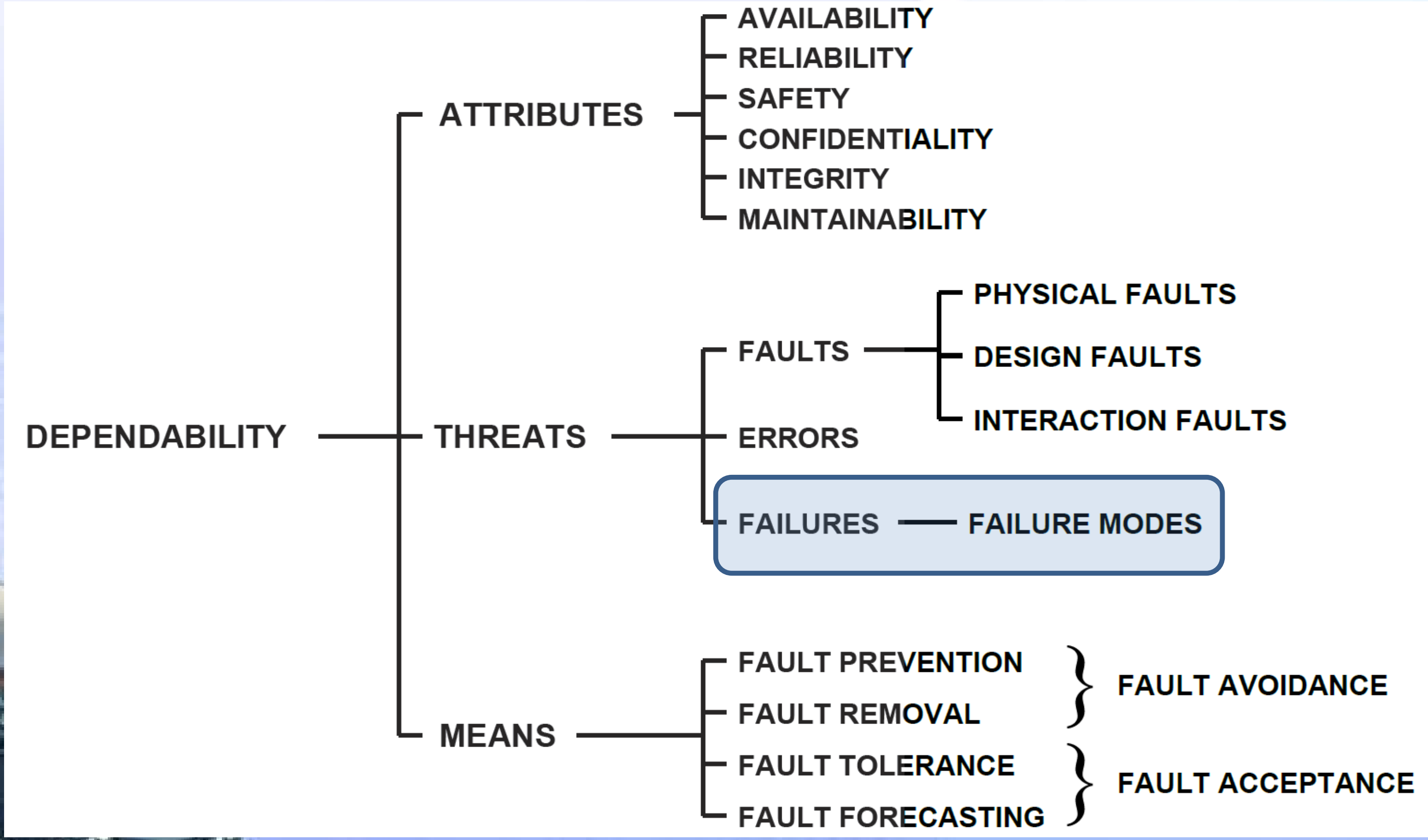


Basic concepts

- ***physical faults*** are faults due to adverse physical phenomena,
- ***design faults*** are faults unintentionally caused by man during the development of the system,
- ***interaction faults*** are faults resulting from the interaction with other systems, including users

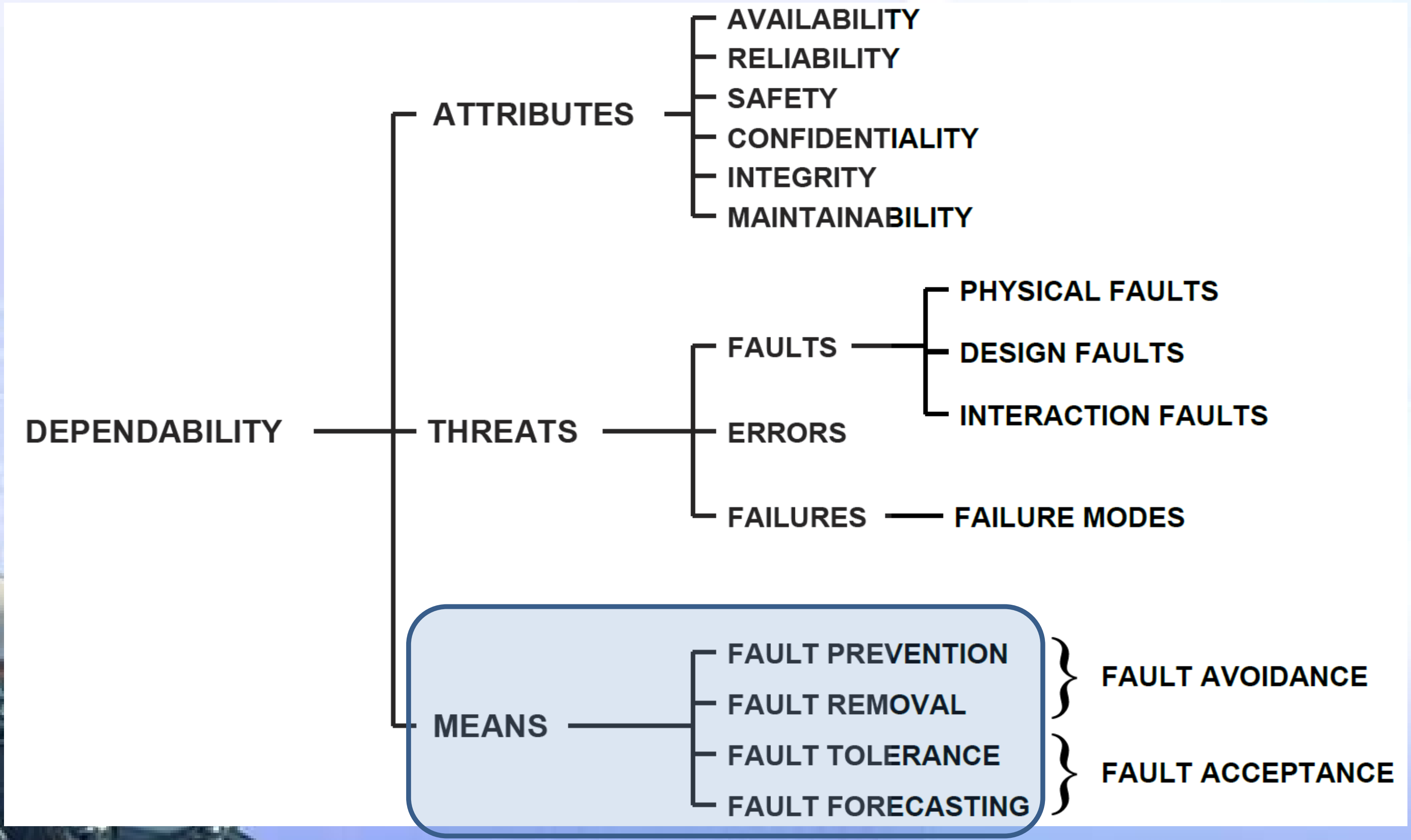
Figure 1: Dependability tree



Basic concepts

- The way in which a system can fail are its ***failure modes***, characterized by the severity and the symptoms of a failure.

Figure 1: Dependability tree



Basic concepts

- ***fault prevention***: how to prevent the occurrence or introduction of faults,
- ***fault removal***: how to reduce the number or severity of faults,

Basic concepts

- ***fault tolerance***: how to deliver *correct service* in the presence of faults,
- ***fault forecasting***: how to estimate the present number, the future incidence, and the likely consequences of faults

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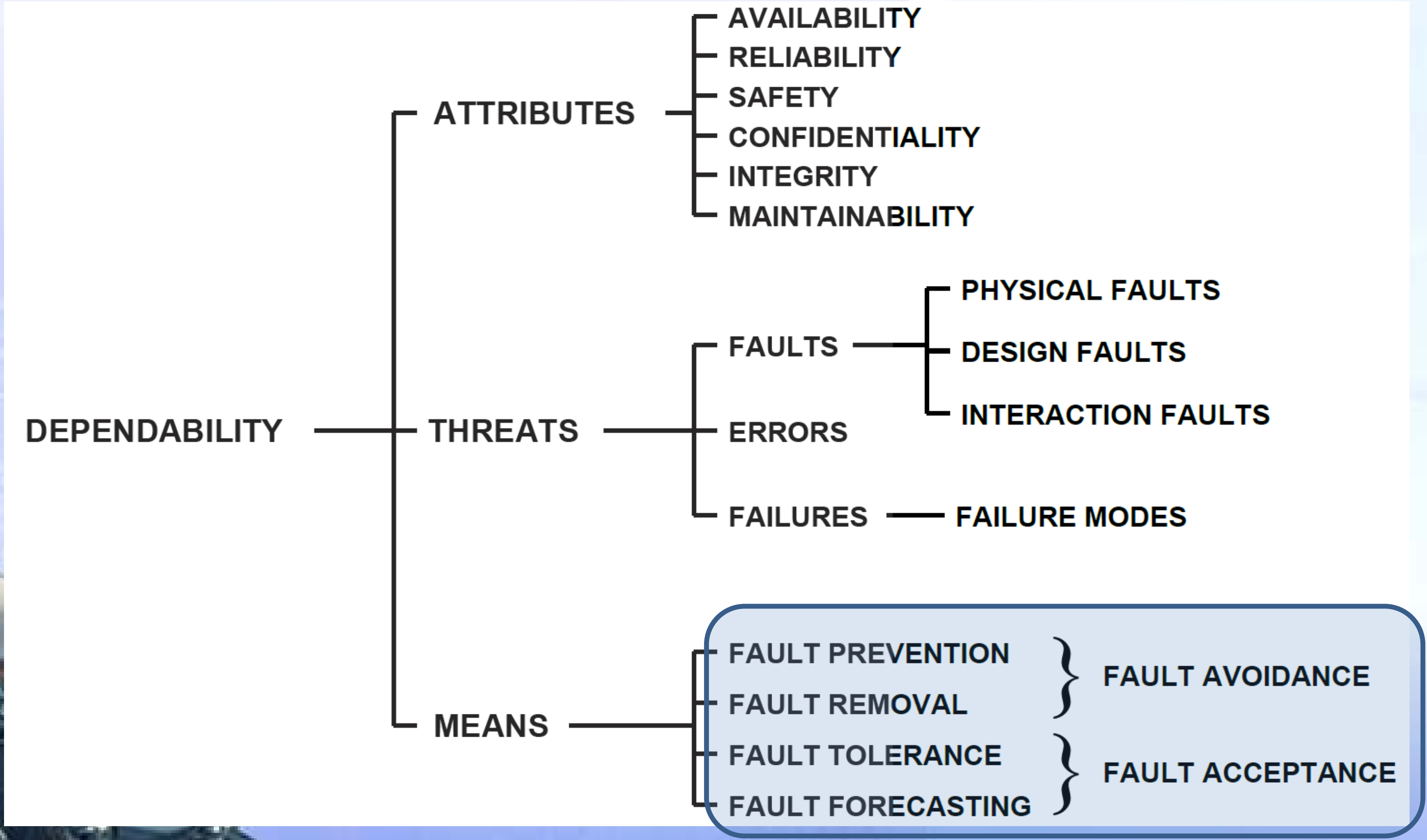


Fault tolerance

- Fault tolerance is intended to preserve the delivery of correct service in the presence of active faults
- Fault tolerance mechanisms:
  - ***Recovery*** transforms a system that contains errors into a state without detected errors

Fault tolerance - Recovery

- *Rollback,*
- *Rollforward,*
- *Compensation*;

** There are fault tolerance mechanisms for each find of faults*

Theoretical Background

Reliability in Multiple Robotics Systems

- MRS need to be reliable as a whole
- Questions to be addressed:
- How to detect when robots have failed?

- How to diagnose robots failures?
- How to respond to these failures?

Theoretical Background

- Challenges of achieve reliability in MRS:
  - Individual robot failure
  - Local perspective
  - Interference
  - Software errors
    - Communication failures

State of the Art

- There are large possibilities of faults in robotics:
  - Robot sensors faults
  - Uncertain environment models
  - Limited power and computation limits

State of the Art

- Robot middlewares try to address the fault detection problem
- Only single parts of the problem are addressed
  - Each one of these middleware monitoring tools starts from scratch
    - Most of them are driven by the capabilities of the robotics middleware and not by the robotics field needs

State of the Art

Individual Robots Fault Detection

- Thresholds: comparing the sensors values with a pre-determined range of acceptable values
- Vote system: based on different redundant components

- Off-line fault detection: Logging is technique where data is collected in advance to be analyzed later

State of the Art

Multiple Robots Fault Detection

- Fault detection systems in MRS have the distribution as a coefficient that increases the complexity
- The MRS must be able to cooperate and communicate with each other
- A networked control system is a requirement to connect all agents through communication

State of the Art

Multiple Robots Fault Detection

- There are several methods and techniques to deal with
- Centralized designed
  - without attending the distributed and decentralized nature

State of the Art

Distributed Artificial Intelligence

- Creation of a supervision system agent
- Able to communicate with other
- Perform monitor tasks

State of the Art

Swarm robotic systems

- Advantage is the redundancy
- Another robot can take steps to repair
- Take over the failed robot's task

State of the Art

Monitoring by Flashes

- Each robot flashes by lighting up its on-board light-emitting diodes
- Neighboring robots are driven to flash in synchrony
  - Error robots do not flash periodically

Research Proposal

Research Problem

Even MRS designed to be robust will face unexpected faults from a very large range of possibilities

Goals

The *goal* of this work is to propose a fault monitoring tool for MRS

- Integrate a infrastructure networking monitoring tool with a robotics middleware

Research Proposal

- **Research Questions**
- Is it possible to adapt an IT infrastructure monitoring tool to detecting faults in MRS?
- How effective this monitoring system will be?

Research Proposal

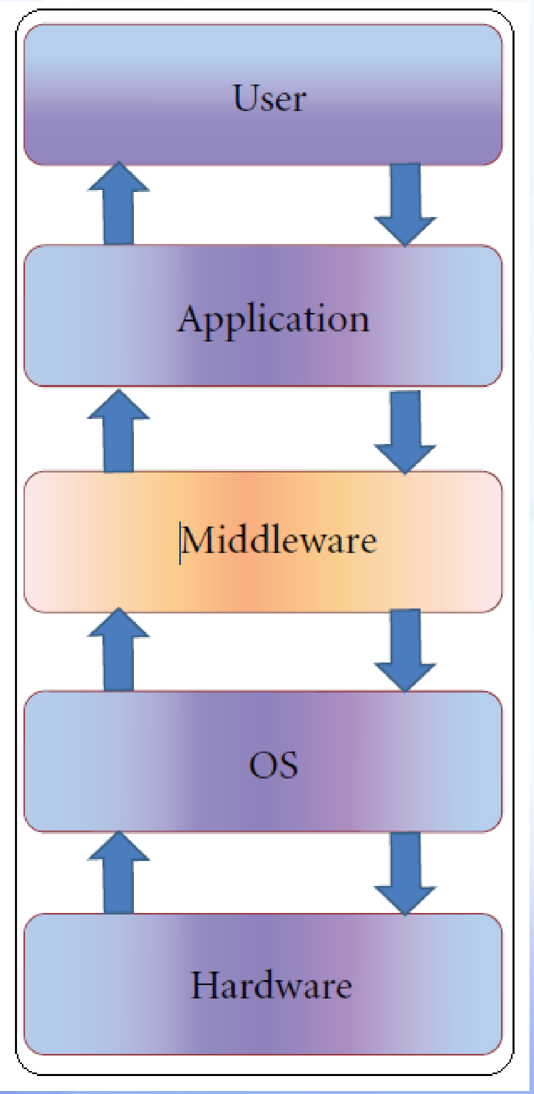
Robots middleware

- Robot Operating System (ROS) is a middleware that provides a communication layer above the host operating system of a heterogeneous computing node

Research Proposal

Robots middleware

ROS



Research Proposal

IT Monitoring Tool

- Nagios provides information about mission-critical IT infrastructure, allowing detecting and repairing problems and mitigating future issues

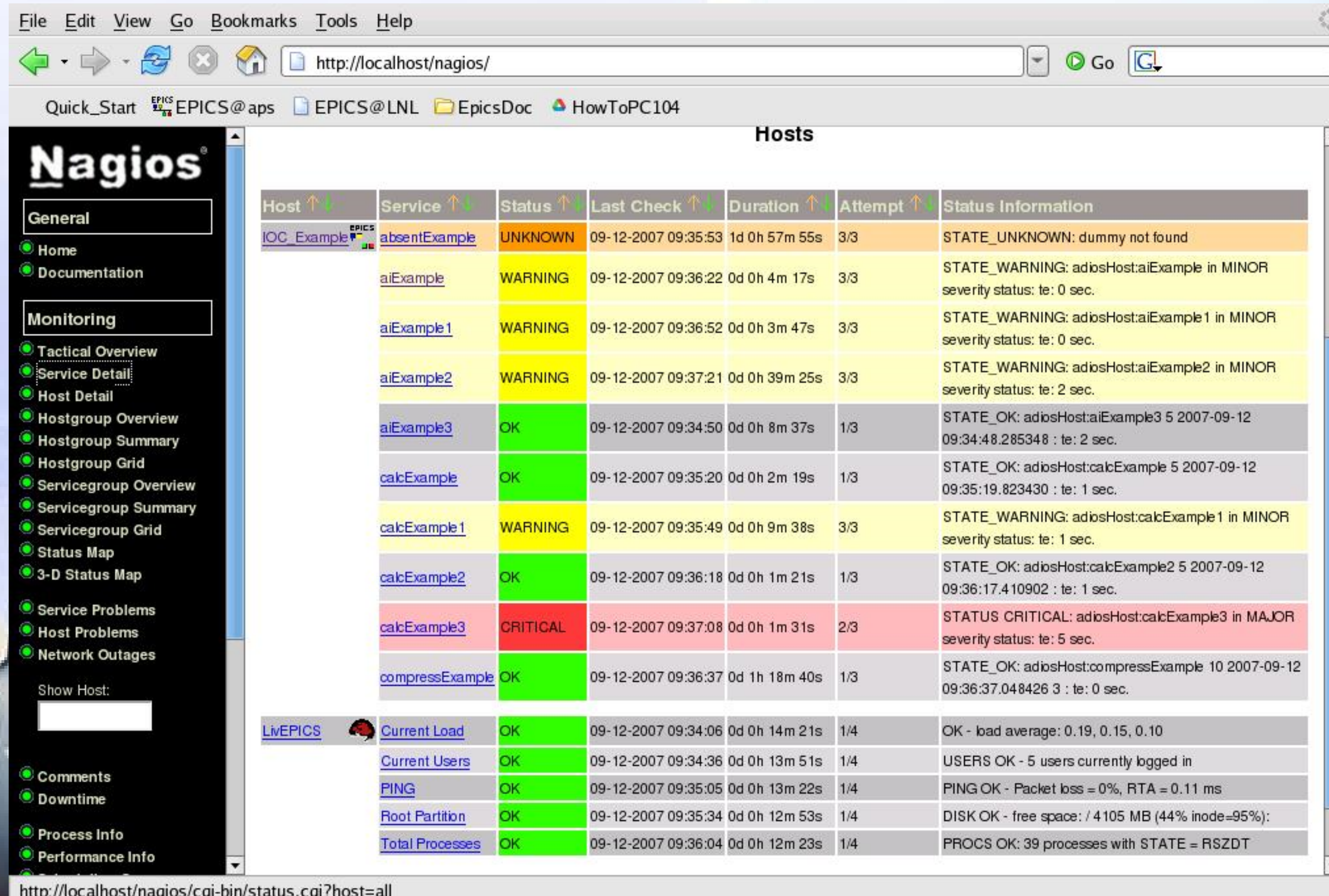
Nagios supports plugins/extensions

Research Proposal

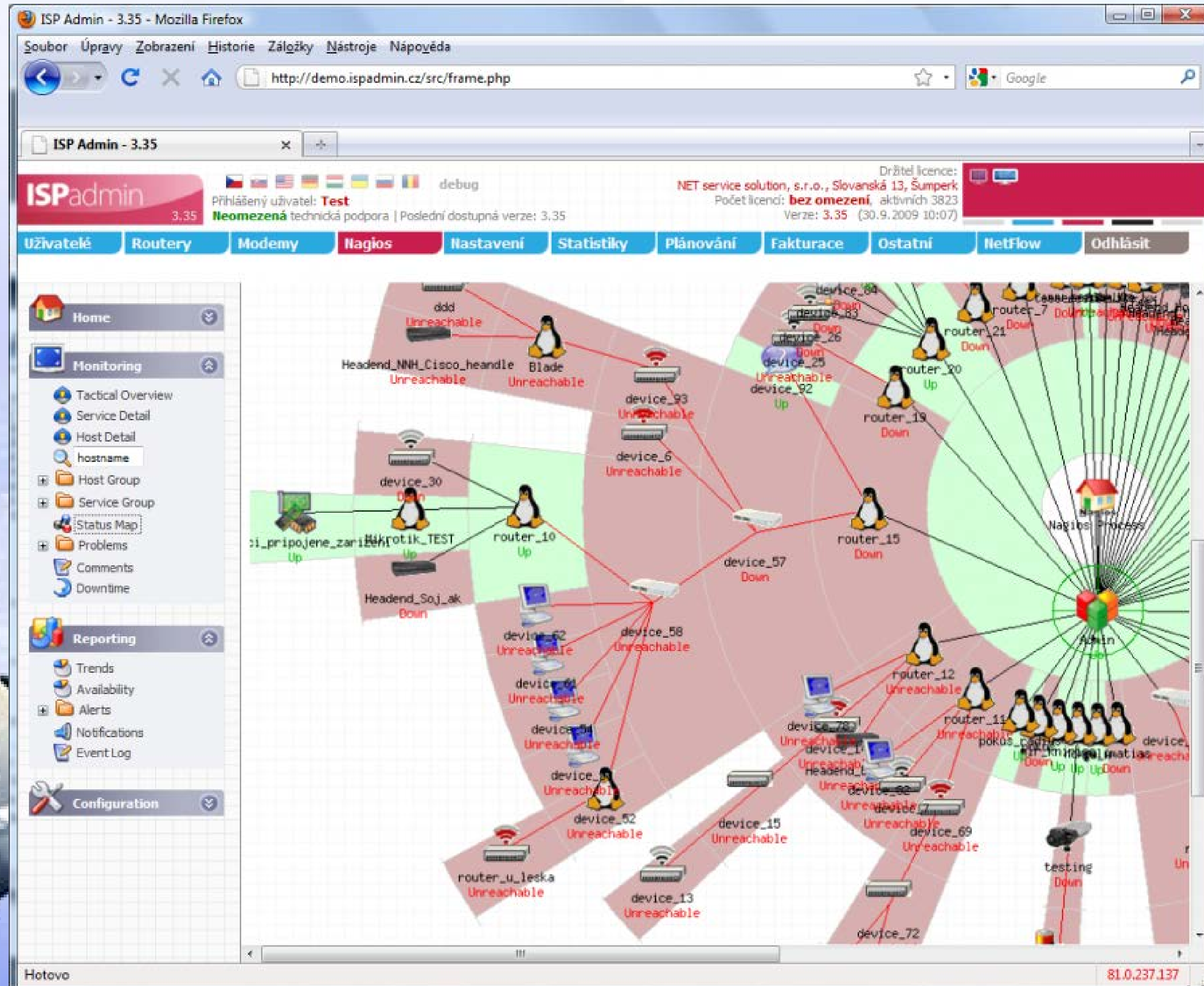
Nagios Plugins

- These plugins can monitor virtually any kind of equipment/devices
- The proposal is to develop a custom plugin to monitor both software information and also hardware information

Nagios screenshots



Nagios screenshots



Nagios screenshots

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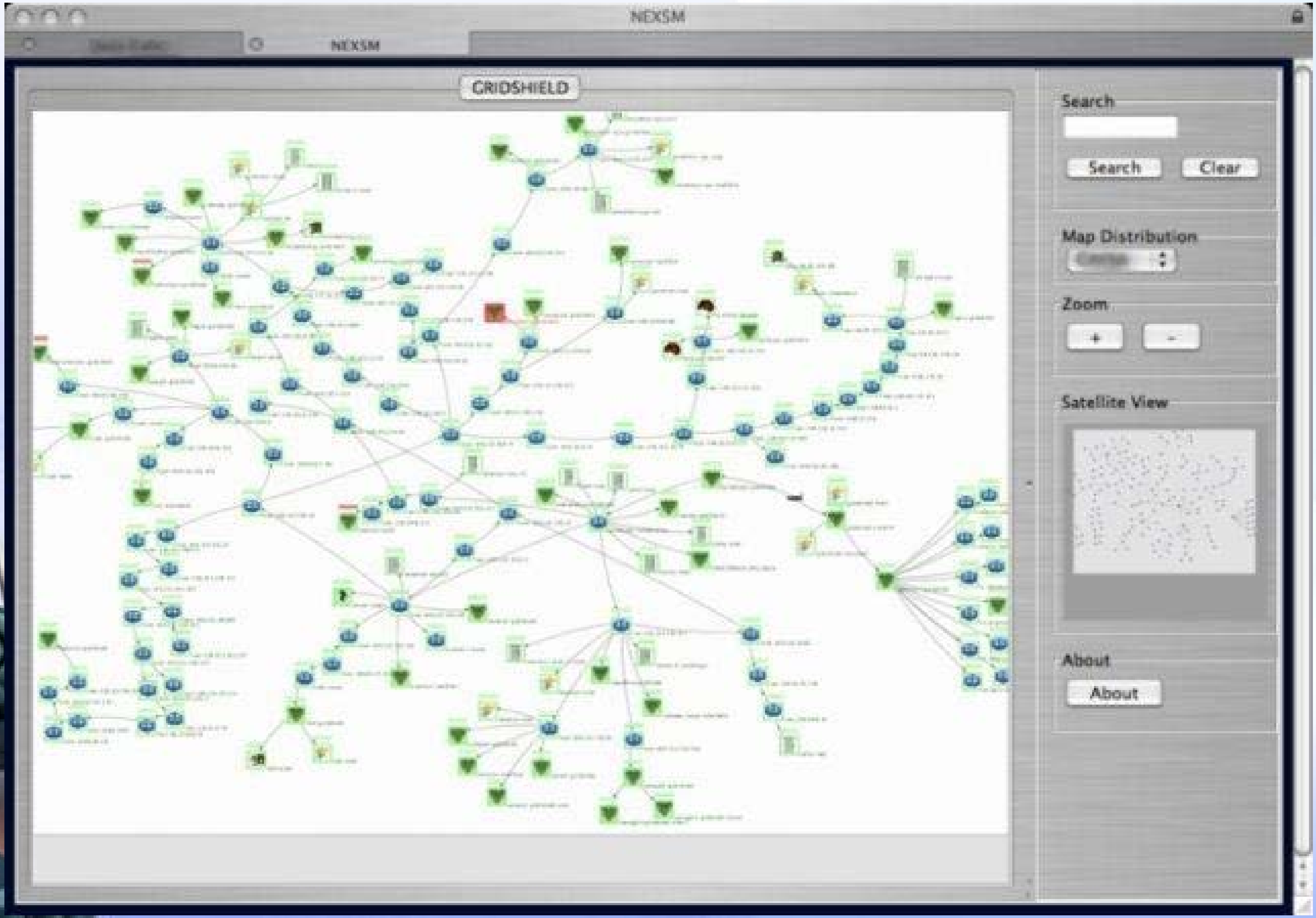

QA


Thank you