OCμ

Organic Computing Middleware for Ubiquitous Environments

Latest Achievements

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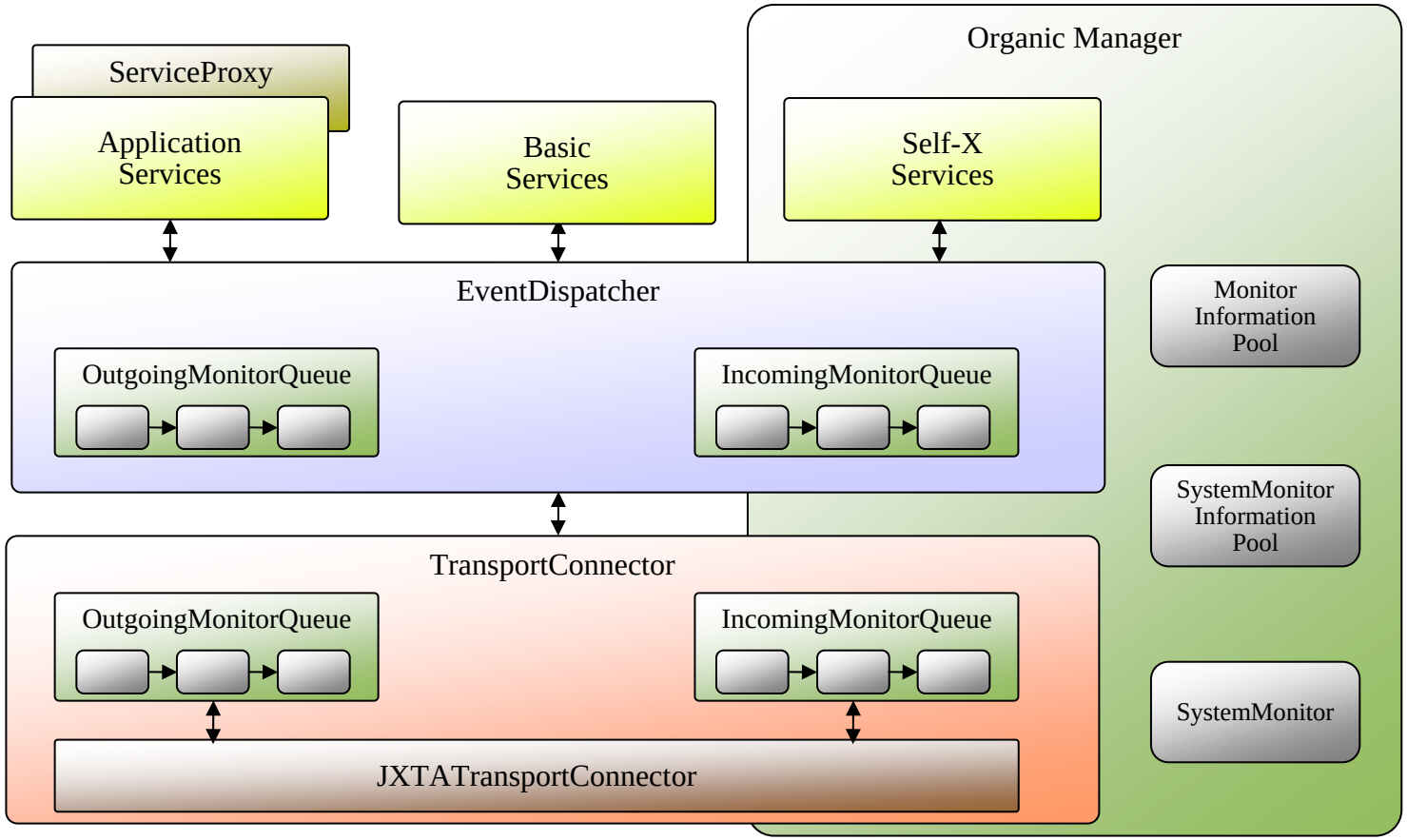
Outline

- OCμ Architecture
  - Self-configuration
  - Self-optimization
  - Self-healing
  - Self-protection
- Summary
- Future Work

Architecture of OCμ

- Service-oriented P2P middleware
- Sophisticated monitoring by monitor queues
- Organic manager
  - System monitors
  - Implements self-x properties as services
- Currently developed in Java and based on JXTA

Architecture of an OCμ Node



Self-configuration (Wolfgang Trumler)

- Based on a cooperative social behavior
- Nodes „vote“ for services they want to start
- Distributed and decentralized approach
- **New:** Cooperation with SAVE ORCA
  - Algorithm used in their applications for reconfiguration
  - ToDo: Formal verification with result checking

Self-optimization (Wolfgang Trumler)

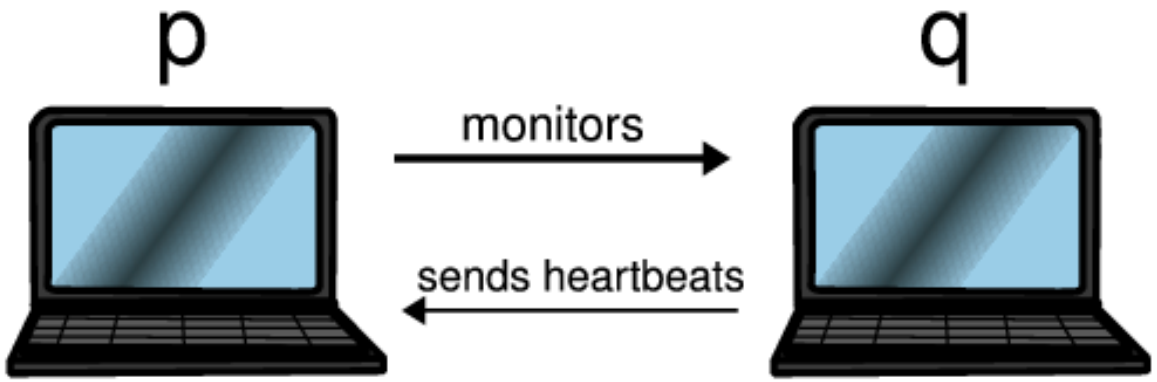
- Inspired by an artificial hormone system
- Nodes exchange current load values piggy-backed on user messages
- Four transfer strategies for service migration
- **New:** (Sebastian Schlingmann)

  Applied to routing of messages in many-core NoCs
  - Algorithm has to cope with increasing number of nodes
  - Down-scaling of the algorithm's computation due to resource-constraints
  - Load information is piggy-backed on NoC messages

Self-healing (Benjamin Satzger)

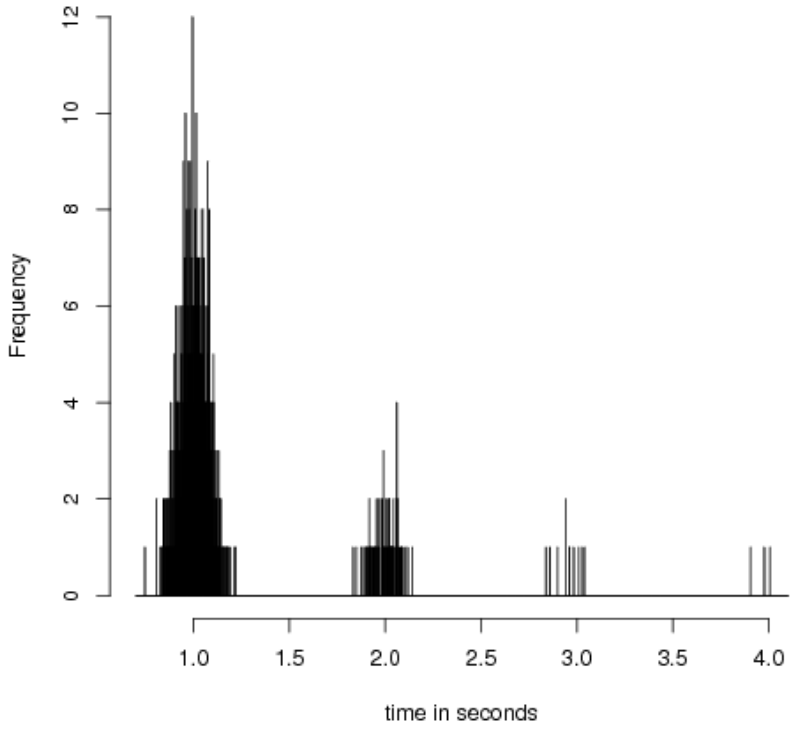
- Failure detection service
  - Adaptive accrual failure detector for detection of node failures
  - **New**: lazy techniques
- **New:** Grouping service
  - Autonomous assignment of monitoring relations for self-monitoring networks
- **New:** Planning engine
  - User: Specification of desired system properties
  - System:
    - Consistency check
    - Automated planning
    - Plan execution
- Self-healing datastore

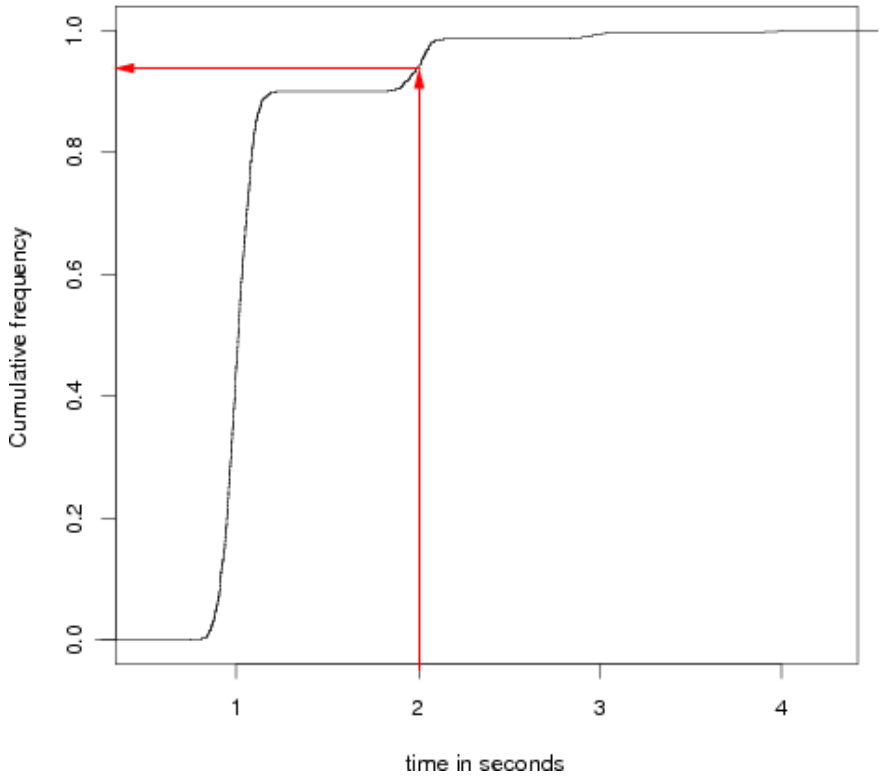
„Accrual“ Failure Detection



- q sends heartbeats to p every Δ_i
- p manages list S of inter-arrival time samples
- e.g. S = [1.083s, 0.968s, 1.062s, 0.942s, 2.037s]
- computation of suspicion information based on S

Failure Detection Service





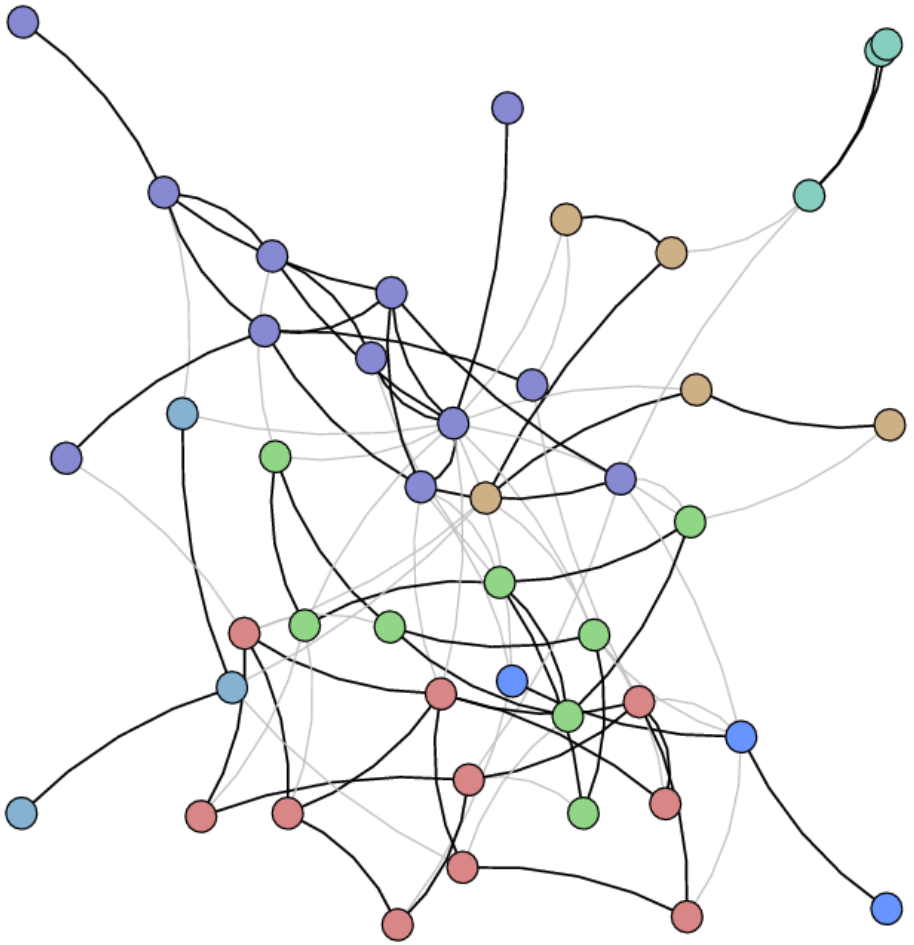
- Accrual failure detector was made adaptive
- New: „lazy“ technique – user messages used as heart beats

New: Grouping Service

- Autonomous installation of monitoring relations
- Monitoring task:

  e.g. failure detection
- Proposal of three

  algorithms



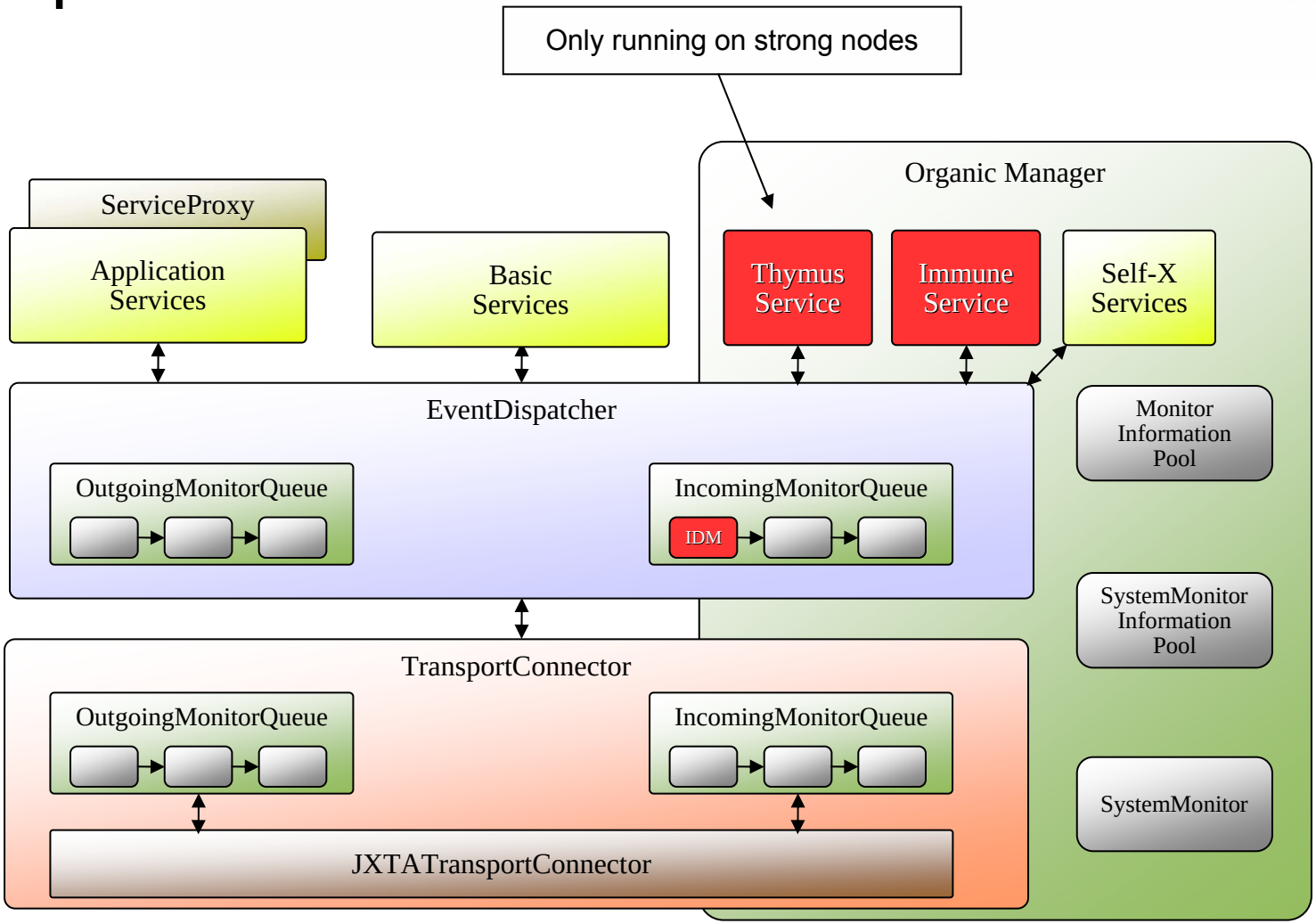
New: Planning Engine

- Allows autonomous self-healing process
- Goal-driven approach
- Trustable and understandable behavior
- Based on extension of POP (Partial Order Planning) algorithm
- Distributed planning process
- Outputs plans in a form suitable for distributed execution

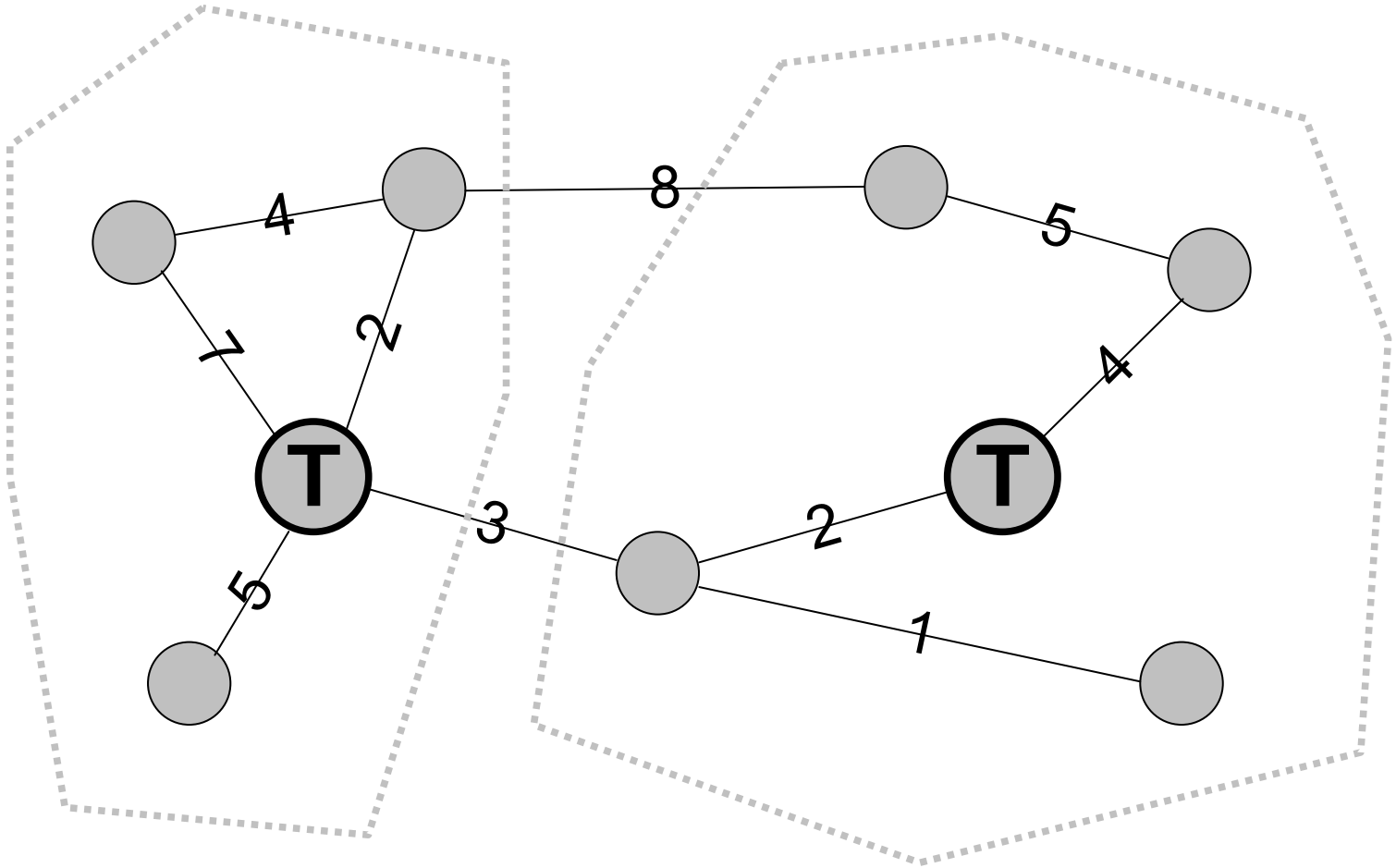
Self-protection (Andreas Pietzowski)

- **New:** Staged security system architecture
  - Authorization
    - Authorized nodes can start and authorize services
    - Authorized services stay authorized while migrating
  - Role management
    - Assign roles to nodes
    - Assign permissions to roles
  - Detection of malicious messages by artificial immunology
    - Antibodies with negative selection
    - Distribution of antibodies throughout the network
    - Update antibodies during system reconfiguration
  - Defending threats
    - Kill services, if possible
    - Isolate nodes, if nothing helps

Self-protection

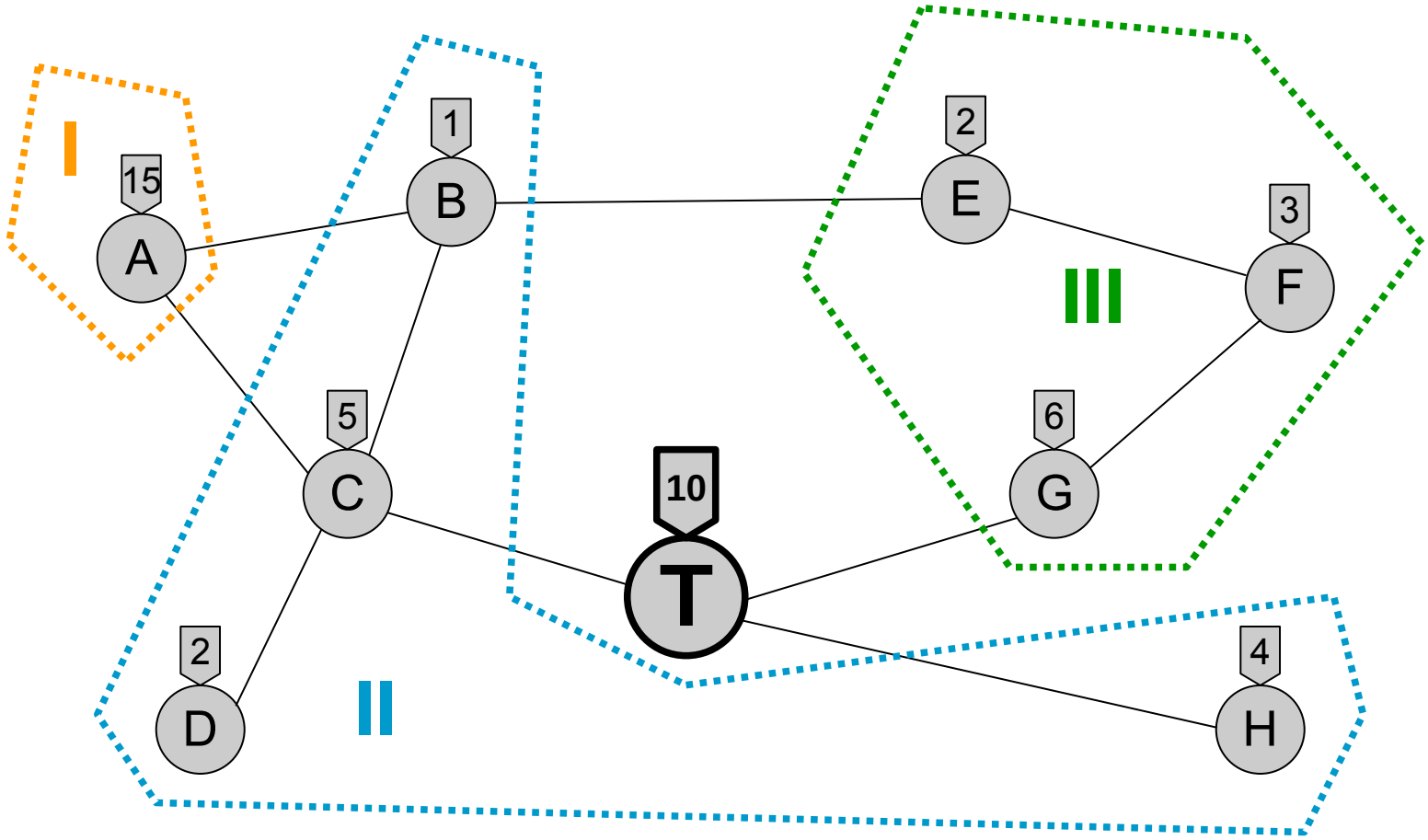


New: Distribution of Thymus Nodes and Registration of the Other Nodes



Numbers denote network latencies

New: Distribution of the Receptors in Case of Low-powered Nodes



Numbers denote receptor capacities

The Problem of the Receptor Groups

- Rotation of receptors
  - Similar to immune system of vertebrates (exchange of antibodies)
  - Drawback:
    - Not all receptors at every node at the same time
    - Communication for exchange of receptors
  - Benefit:
    - Not all nodes are vulnerable against the same intruder in a time
    - The only way if the capacity of a group under-runs the required space
- Rotation of messages:
  - Drawback:
    - Delay of the messages
  - Benefit:
    - Same protection like strong nodes

Summary

- OCμ prototype matured
- Sophisticated self-configuration, self-optimization, self-healing, and self-protection
- Cooperation with SAVE-ORCA of University of Augsburg
- Applied by the ChemOrg project of University of Jena
- Self-optimization transferred to NoC routing in manycores

Future Work

- Improved self-healing mechanisms
- Add trust techniques:
  - Examine trust metrics and values [already in progress]
  - Implement trust aspects and trust techniques in OCμ
- Application to real embedded systems
- Migrating OCμ to a hardware Java multiprocessor (based on Jamuth/Komodo microcontrollers) [already in progress]

Publications

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- Wolfgang Trumler, Sebastian Schlingmann, Theo Ungerer, Jun Ho Bahn, Nader Bagherzadeh, Self-optimized Routing in a Network-on-a-Chip, IFIP 20th World Computer Congress, Second IFIP TC 10 International Conference on Biologically-Inspired Collaborative Computing , September 8-9, 2008
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- Wolfgang Trumler, Jörg Ehrig, Andreas Pietzowski, Benjamin Satzger, Theo Ungerer. A Distributed Self-healing Data Store,. The 4th International Conference on Autonomic and Trusted Computing (ATC-07), Hong Kong, China, July 11-13, 2007
- Wolfgang Trumler, Andreas Pietzowski, Benjamin Satzger, Theo Ungerer. Adaptive Self-optimization in Distributed Dynamic Environments. First IEEE International Conference on Self-Adaptive and Self-Organizing Systems, Boston Massachusetts, USA, 9 - 11 July 2007
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- Benjamin Satzger, Andreas Pietzowski, Wolfgang Trumler, Theo Ungerer. Variations and evaluations of an adaptive accrual failure detector to enable self-healing properties in distributed systems. ARCS'07: Architecture of Computing Systems, Zurich, Switzerland, March 12-15, 2007, Published in "Lecture Notes in Computer Science" (LNCS), ISSN: 0302-9743
- Benjamin Satzger, Andreas Pietzowski, Wolfgang Trumler, Theo Ungerer. A new adaptive accrual failure detector for dependable distributed systems. The 22nd Annual ACM Symposium on Applied Computing, Seoul, Korea, March 11 - 15, 2007
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