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SEN4:
Multi-agent and Adaptive Computation
(including the former PNA4)

Han La Poutré

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Members 2011

- Tenured researchers
  - Han La Poutré
    - Adaptive multi-agent systems: market mechanisms, computational intelligence
  - Peter Bosman
    - Evolutionary computation, multi-objective optimization
  - Eric Pauwels
    - Semantic sensor networks, image processing
- Temporary researchers
  - 7 Ph.D. student positions (3+4)
  - 2 Postdoc positions (1+1)
- Scientific programmers (2; SEN4,PNA4)

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History of SEN4 and PNA4

- PNA4 merged into SEN4 in 2010
  - Independent groups in 2005 – 2009
  - PNA4:
    - 3 tenured researchers in 2005
    - 2 left PNA4
      - To other group (stochastics); and due to serious illness
    - One remaining researcher: Eric Pauwels
  - SEN4:
    - 2 tenured researchers in 2005
    - 1 moved to other group (life sciences)
    - 1 new tenure in 2010: Peter Bosman
      - After postdoc and tenure track 2004-2010
- Techniques of PNA4 converged to those of SEN4

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Fundamental Techniques: Design and Analysis

- Decentralized paradigms: multi-agent systems
  - Software agents
    - Economic paradigms (market mechanisms, auctions, negotiation)
    - Adaptive strategies: computational intelligence, heuristic algorithms
  - Sensor agents
    - Extracting semantics from sensor networks
    - Signal processing and computational intelligence techniques

- Computational intelligence techniques (CI)
  - Evolutionary algorithms (EA), reinforcement learning, hybrid heuristics
    - Estimation-of-Distribution Algorithms (EDAs)
    - Multi-agent learning

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Key Research: Agents in Markets and Games

- Repeated bidding in markets / economic games
  - Limited information, dynamic environments
    - Market-based control
  - Adaptive agent strategies
  - First-ever approach for risk averse bidders
  - First-ever approach for priced options

- Adaptive negotiation strategies and utility modeling
  - Interdependent negotiation issues
    - Complex
    - Types of opponents/customers
  - First-ever efficient and scalable methods
    - Graphical utility models, online adaptation

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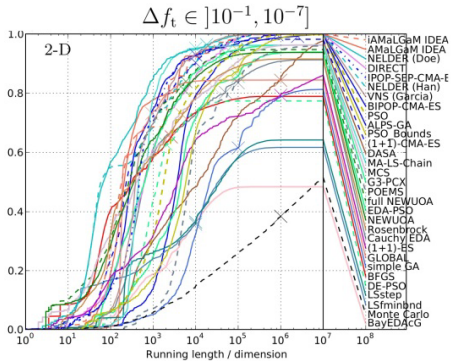
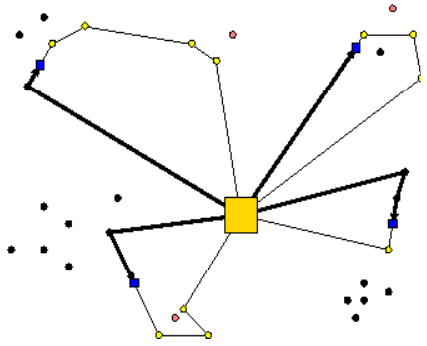
Key Research: Black-Box Optimization

- Advanced Evolutionary Algorithms
  - Estimation-of-Distribution Algorithms (EDAs)
    - On-the-fly statistical analysis
  - Optimization with (complex) simulations
    - Robust against many problem features
  - AMaLGaM: ranked world-class



- Dynamic and multi-objective versions
  - Vehicle routing with on-the-fly requests
  - Simulation developed (black box)
  - First EA with dynamic policy optimization
    - Also: on-the-fly learning and prediction
  - Outperforms earlier EAs



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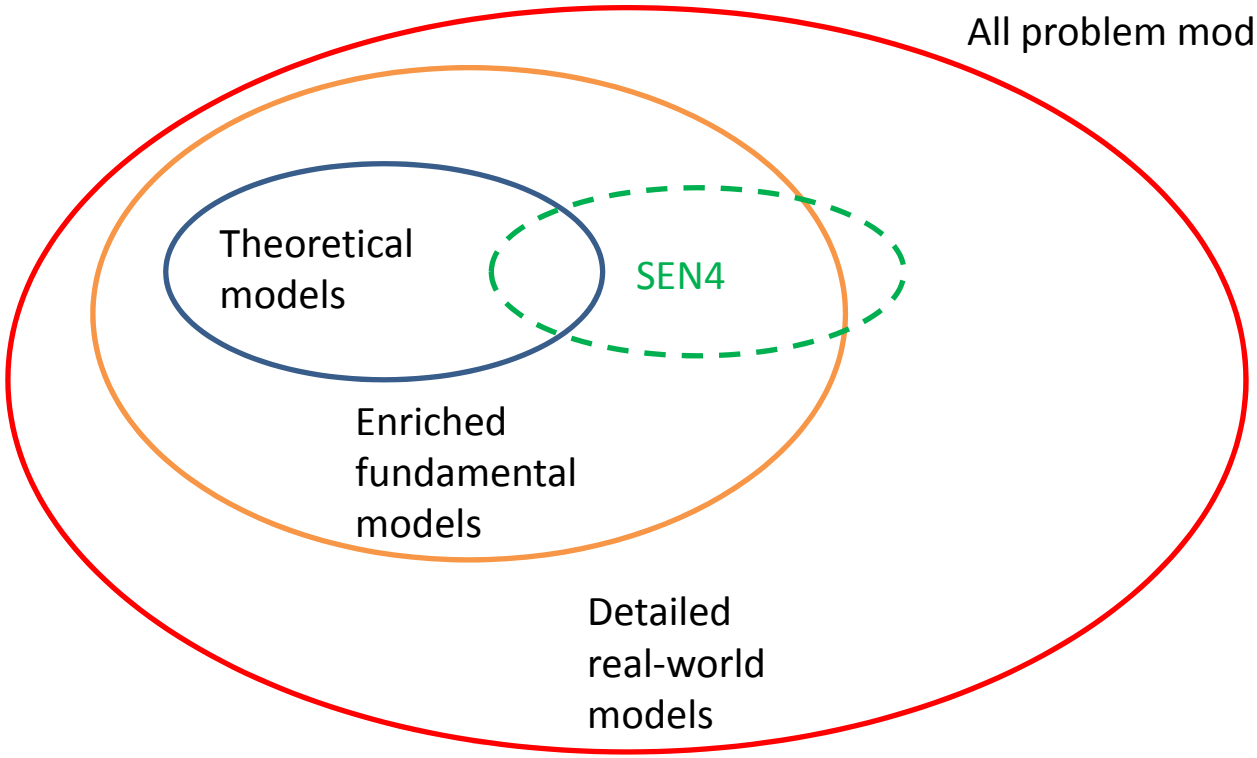
Key Research: Sensor Agents and Semantics

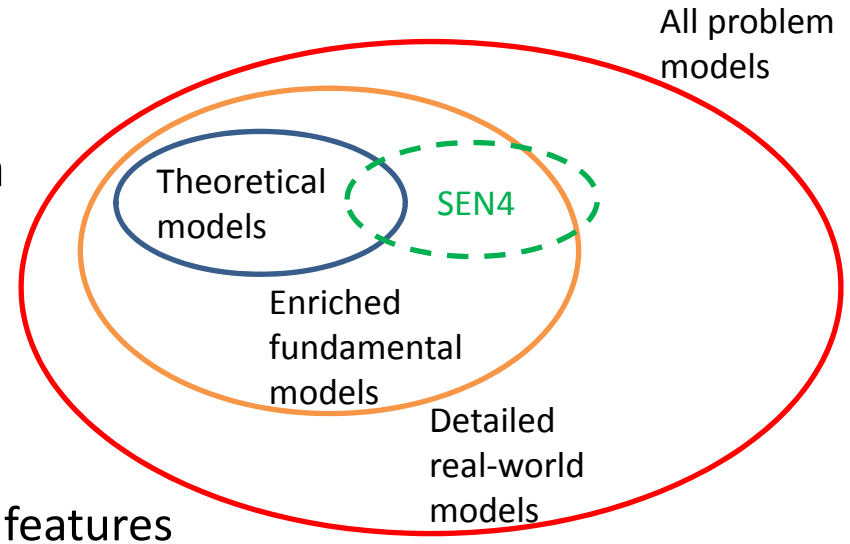
- Semantic sensor networks
  - Robust high-level interpretation of sensor data
    - Combination of different sensory modalities
    - Integration of data from various localities with a model
    - Signal processing and computational intelligence techniques
- Image indexing, retrieval, and understanding
  - Generation of content descriptions of images
    - Shape characterization
    - Sensors: cameras

Positioning and Strategy of SEN4: *Fundamental, Inspired by Applications*



Positioning and Strategy of SEN4: *Fundamental, Inspired by Applications*

- Enriched fundamental problem models
  - Most-essential additional features
    - E.g. timing constraints
  - Realistic (multiple) objectives
  - Uncertainty: limited information
  - Repetition
  - Dynamics
- Additional goal
  - Robustness of approaches
    - Against several detailed problem features
- Projects
  - Multidisciplinary
    - VOS Logistics, APM Terminals, AMC, KEMA, Enexis/Essent
    - SEN3, INS3, MAC1, MAC2, PNA1, PNA2
    - Universities, Lifewatch



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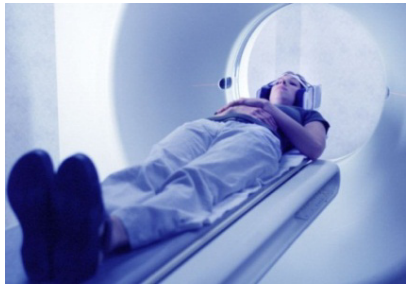
Problem Domains: Computational Sustainability

- Decentralized and adaptive logistics
  - Transportation (market-based control)
  - Health care (adaptive)

- Sensing and semantics
  - Novelty detection (calamities, energy)



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New Challenging Problem Domain: Smart Energy Systems (SES)

- Started with first interest in energy 4 years ago
  - Preparation, domain knowledge, and networking
- Now:
  - 5 Ph.D. and 1 postdoc position
  - Involvement in networks
    - NWO SES committees
    - EIT ICT Labs: SES core team

- Perfect match with the techniques of SEN4
  - "Killer application" for multi-agent systems
    - Decentral, dynamic, uncertain, multi-objective
    - Demanded by the energy field/experts
  - New challenging problems in CS

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Scientific Challenges

- Goal 1:
  Fundamental development of techniques themselves
  - See above

- Goal 2:
  Models and techniques for the smart energy domain
  - Smart grids
    - Energy supply/demand matching (markets)
    - Capacity planning
    - Network state determination
  - Energy in Smart Buildings
    - Detection of usage and generation
    - Online optimization of usage and generation
  - Relevant techniques
    - Agent systems, sensor agents, agent-based simulation, markets
    - CI, black-box optimization, multiple objectives

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SWOT

- Strengths
  - Publications in high-quality forums
  - Fundamental research with societal relevance
    - With societal institutions, companies, and academia
    - Multidisciplinary projects
  - Increasing roles in networks and science policy
- Weaknesses
  - Reduction of former PNA4 group in size
  - Difficulties with funding for health care logistics with ICT
    - More eye-catching areas: telemedicine, EPR

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SWOT

- Opportunities
  - New important application area “Smart Energy Systems”
    - Fits very well the expertise of SEN4
  - Combination of sensor systems and adaptive techniques
- Threats
  - Acquisition of high-quality Ph.D. students
    - Fundamental research inspired by applications
    - Competition with companies
  - Decrease in funding for ICT research by the government

Conclusion

- High-quality publications and results
- Research together with other domains and companies
- Well-positioned for the future: smart energy systems
- Good mix of tenured researchers
- Increasing roles in scientific networks and policy