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VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Agent Applications in Production Planning

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Problems Mapping and AI Methods

- Real problems constraints vs. standard problem definition
- Need of adding/relaxing problem constrains based on good understanding of the both real problem and solution methods
- Lot of planning algorithms in AI, but limited applicability to real problems
- Problems often computationally complex → AI approaches based on heuristics → non-trivial mapping to real problem
- Complex (non-explicit) functional and non-functional requirements

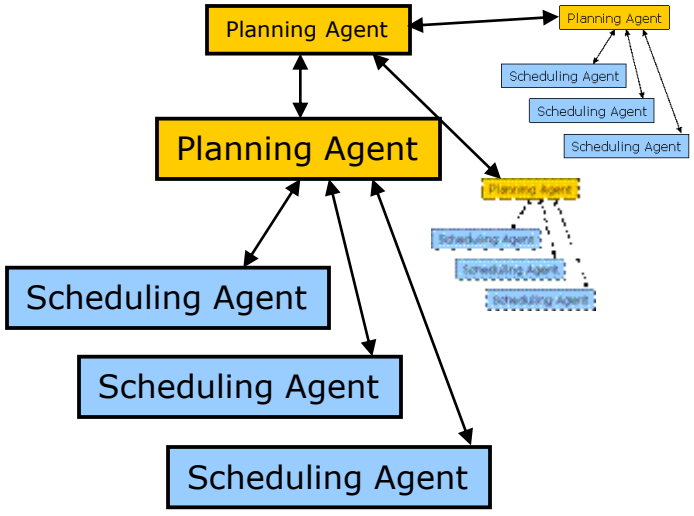
Problems Mapping and AI Methods

How to bridge the gap between real world problems and AI solutions?

	Real problems	Classic AI problems
Optimization criteria	complex, multi-attribute	specific measure
Constraints	Complex constraints, priorities, hard or soft, nonfunctional …	explicitly defined, not conflicting
Environment	non-deterministic, dynamic, decentralized, uncertain	usually solve deterministic, static, centralized version
Performance	fast, stable, feasible sufficient solution	optimal solution, algorithm features proofs
Deployment	data/system integration, reliability	experimental purposes

Agent Based Production Planning

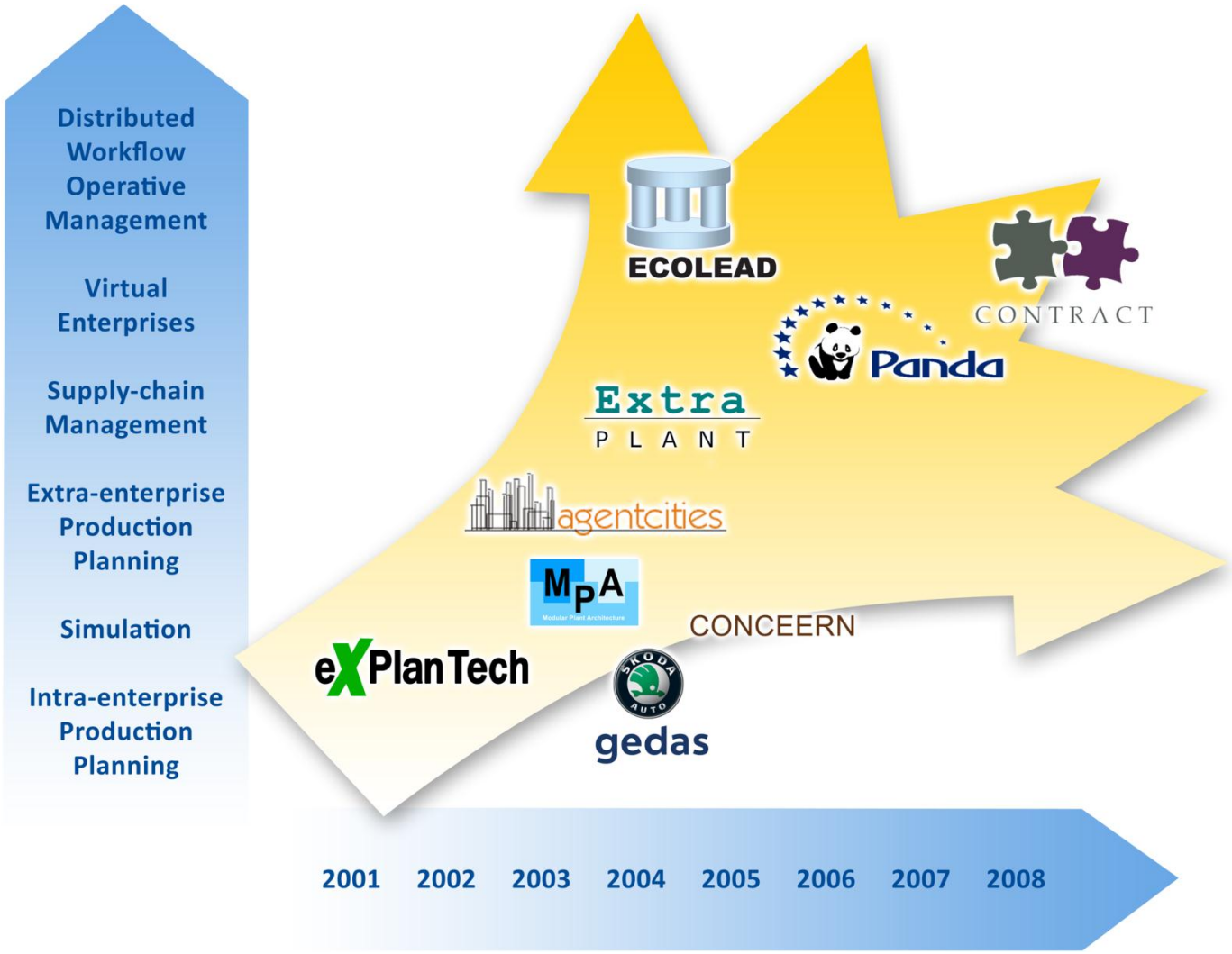
- Decentralized approach
- Respects natural hierarchy of the system
- Based on hierarchical planning and decomposition principle
- Combination of planning and resource scheduling
- Allows using of wide variety planning strategies/heuristics
- Open system, high flexibility
- Reconfiguration in runtime
- Tight connection to simulation
- Based on
  - Problem decomposition
  - CNP allocation
  - Local optimization heuristics



Agent Based Production Planning

- Modeling and simulation of production workflows and supply chain integration
- Methods based on modeling of factory departments, workshops, resources …
- Various planning and optimization approaches – balance between quality of solution and computational efficiency
- Incorporating external departments/suppliers into planning process (intra-enterprise/extra-enterprise planning)
- Flexible planning methods to cover uncertainty and dynamism of the real environment

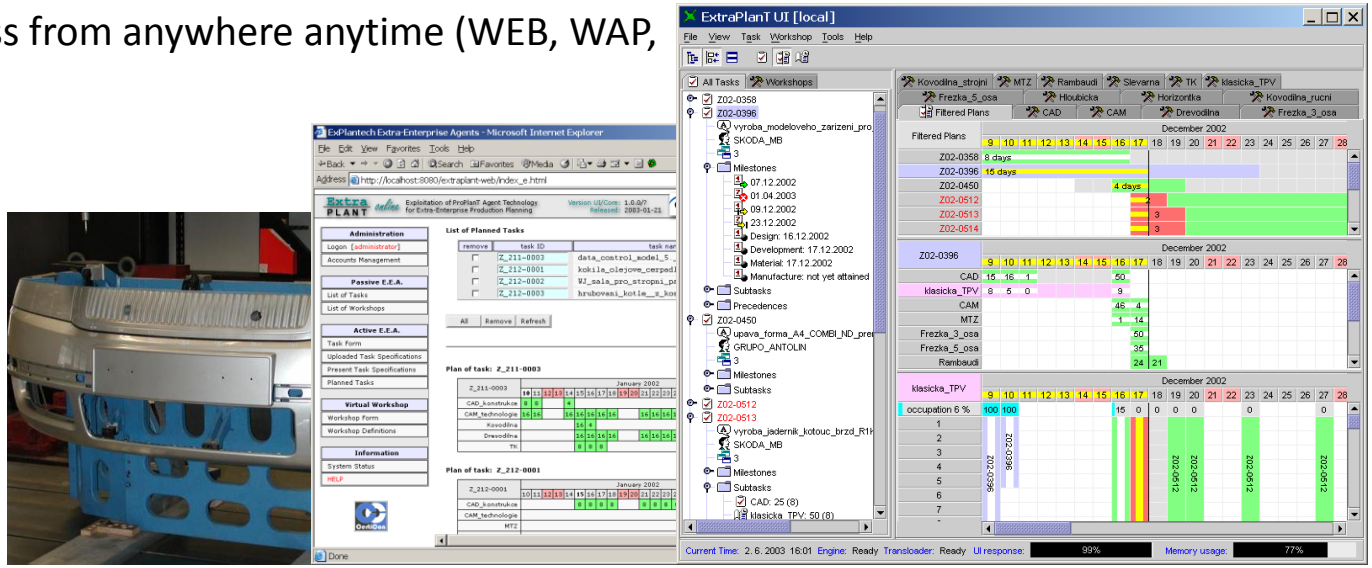
Agent Based Production Planning



Production Planning/Scheduling

Production planning for manufacturing

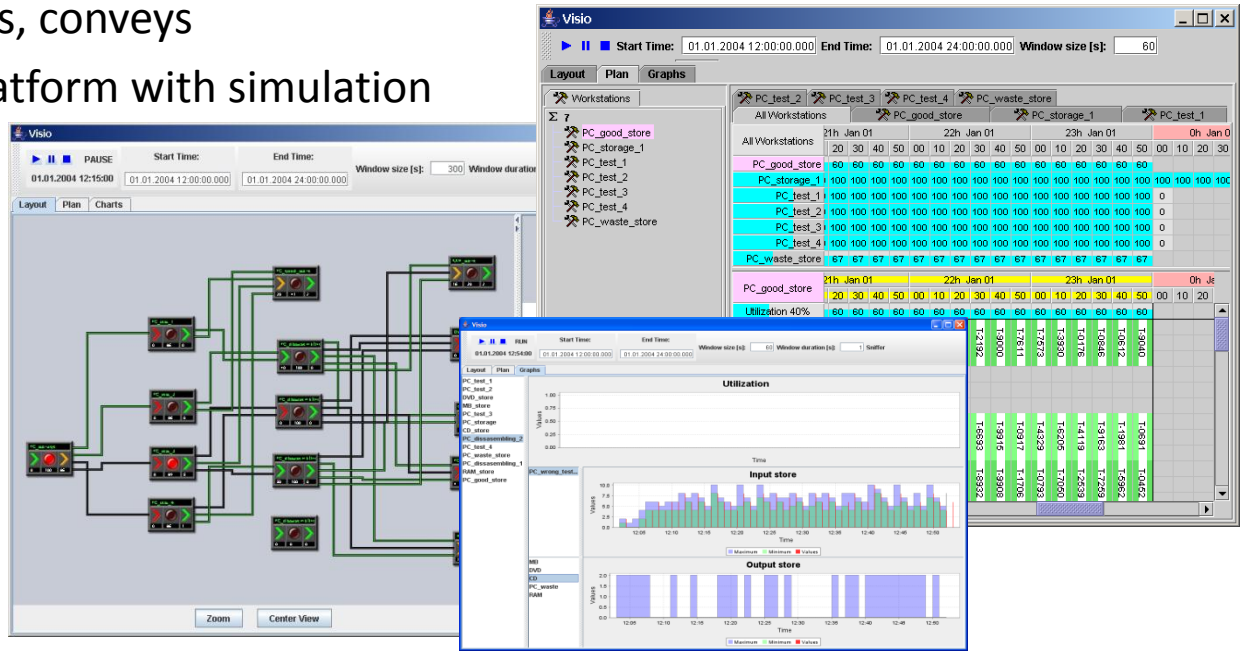
- Production planning multi-agent system in pattern manufacturing
- Production feedback and dynamic replanning
- Optimal distributed schedule minimizing weighted delay of tasks
- Based on sub-tasks prioritization by critical path analyses
- Linking suppliers and collaborators – building virtual enterprise
- EEAgents – access from anywhere anytime (WEB, WAP, PDA)



Shop Floor Simulation

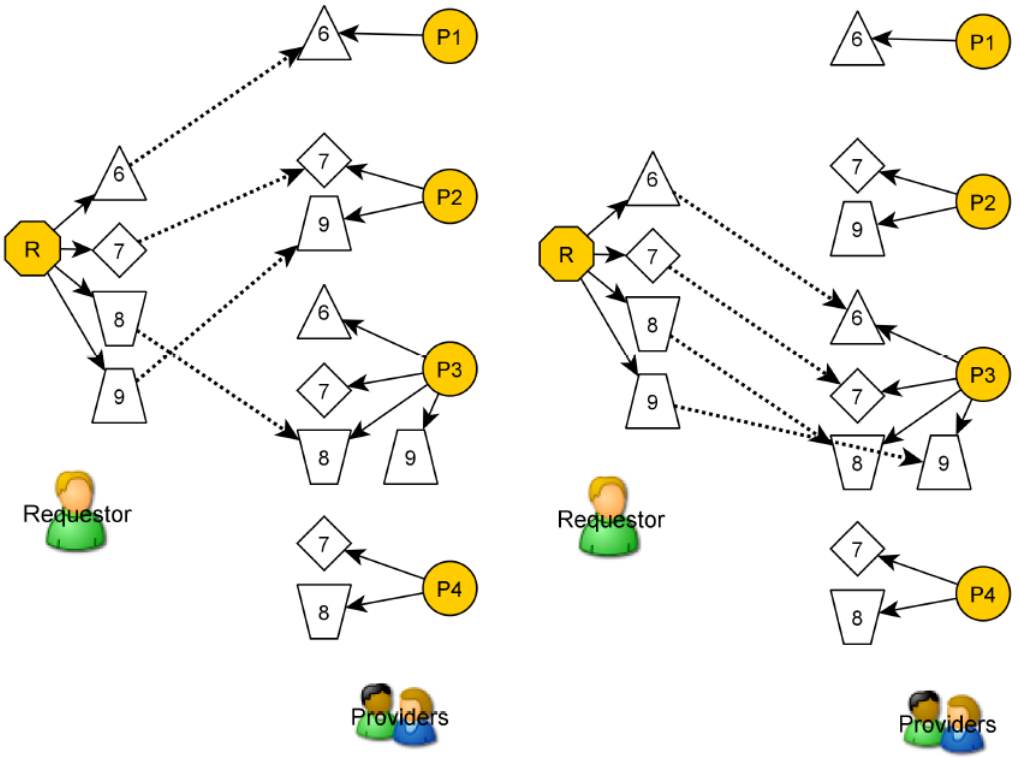
Shop floor simulation

- Agent-based resource modeling
- Production flow simulation
- Production unit performance models/breakdowns
- Input/output buffers, conveys
- Utilizing A-Globe platform with simulation support



Virtual Organization Formation

Formation of VO is mapping the collaboration request (business opportunity) to the set of partners



Virtual Organization Formation

Uses Acquaintance model based on pair wise constant approximation

It is **sound** and **complete** for non-increasing pricing function

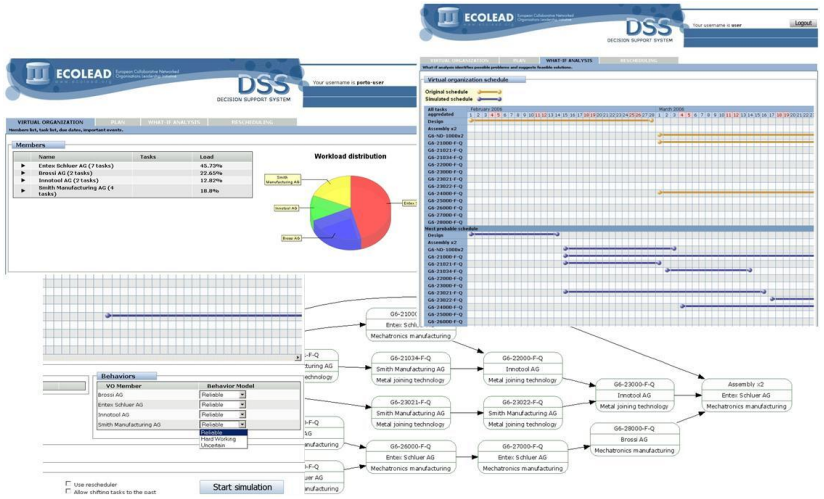
Provides **any-time** solution

Partners		6	6	6	6	6	6
Subtasks per partner		16	16	17	17	18	18
All subtasks		32	32	34	34	36	36
Task size		11	12	11	12	11	12
Subtask coverage		3,00	3,00	3,00	3,00	3,00	3,00
Deal Space		177 147	531 441	177 147	531 441	177 147	531 441
Maximal model size		393 210	393 210	786 426	786 426	1 572 858	1 572 858
Average Iteration in first Task		7,00	6,83	7,83	8,65	6,86	7,14
Average Proposal Count in first Task		58,83	64,17	63,33	56,83	59,29	63,29
Model size after 10 tasks		312	283	301	229	328	261
Percent from Maximal model		0,0793	0,072	0,0383	0,0291	0,020854	0,016594

Decision Support System

Business process modeling and simulation

- Intra-enterprise or supply-chain/network management
- Autonomous agents based modeling
  - Each actor (machine, team, division, company, etc.) is modeled separately to consider autonomous state, behaviors and capabilities, past performance and experience
- Collective simulation (what-if analysis)
  - Generation of random performance variations, statistical simulation based on Monte-Carlo method
- Agent based planning
  - Planning, scheduling and allocation is based on negotiation between agents using actor models



Distributed Team Planning

Logistics in disaster relief scenario

Dynamic non-deterministic environment

- *Distributed planning* – planning in the mentioned environment is practically realizable only as a distributed process
- *Distributed resource allocation* – integral part of the planning process is resource allocation both of the acting entities in the world and of the static resources
- *Distributed plan execution and synchronization* – constituted distributed plan consisting of several personal plans has to be executed by the entities
- Implemented approach provides polynomial tasks allocation heuristics with complexity $O(n^{2m}/2m)$ for m-level of planning hierarchy and n-agents in each level

Distributed Team Planning

Vehicle Routing Problem

Planner: agent based solution (polynomial)

- CNP-like allocation
- Local TSP heuristics
- Backtracking due to capacity constraints
- Delegation and reallocation strategies
- Continuous solution improvement using strategies adaptation
- Easy adaptation to other problems (m-TSP, k-TRP, …) and custom constraints
- Robust to high degree of dynamism

Vehicle Routing Problem

Stable performance on all available benchmarking instances

Error from optimal (best known) solution from 0 to 22%