AGENTS ARE COMING:

DEPENDABILITY PROBLEMS IN A NEW PARADIGM

Jack Goldberg
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SUMMARY

Agents

- A new software paradigm for distributed systems
- High momentum in research and practice
- Serious dependability problems
- Most current proposals take dependability for granted

QUESTIONS ABOUT AGENTS

What are agents and how do they differ from other software?

What is their attraction?

Who is working on them?

What are their dependability problems?

What can be done to improve their dependability?

What are some research issues?

WHAT ARE AGENTS AND HOW ARE THEY DIFFERENT?

Agents implement the wishes of human users without direct supervision

Characteristics:

Semi-autonomous, proactive
Large numbers, distributed, clonable
Unbounded and persistent
Independent or cooperative
May produce only partial results or no results
Informational (“bots”) or physical (“robots”)

TYPES OF AGENTS (CURRENT PROTOTYPES)

Task-specific: Do a single task in a limited domain
-- Data retrieval, report, control

Powerful: Adaptively pursue goals in complex environments
-- Knowledge, Beliefs, Goals, Intentions

Grouped: Collective action of extremely simple contributors
-- Flocks, streams, barriers

WHAT IS THEIR ATTRACTION?

Agents are seen as the appropriate paradigm for the next generation of computing systems:

Transcend GUI-moderated user control
Automate internet services
Support continuously-available control and robotics
Extend and support distributed human teams
Organize large, parallel, distributed computations
Implement pervasive, adaptive, continuous, dependable system infrastructure
Support “ubiquitous” computing environments

EXAMPLE BEHAVIOR

Primary services

Seek and return a value when data is found
Transactions, remote control
Dynamically manage large computations

Infrastructure

Deputize clones to help in large or remote workspaces
Balance workloads
Monitor progress and errors
Protect local resources from intrusion
Reconfigure damaged resources

WHO IS STUDYING THEM?
WHO IS USING THEM?

All the research universities (many agent-focused centers)

Major independent and commercial research laboratories

Many internet companies

World-wide activity

Strong DARPA support

SAMPLE APPLICATIONS

Search of databases, local and network
Multi-faceted optimization for engineering design
Telecom/power system management
E-Commerce – shopping, auction, negotiation
Scientific Computing – data managers
Robots – domestic, industrial, space
Health care -- monitoring, resource management
Simulated-human user interfaces and help services

WHAT ARE THE DEPENDABILITY PROBLEMS?

Some pathologies

Exponential cloning –“Sorcerer’s Apprentice”
Cascaded damage --Wild fire
Overloading of resources -- Inappropriate demands
Unexplained absence of a result -- No data/bad response
Inconsistency and deception among agents -- Byzantiana
Unanticipated group behavior – Crowd pathology
Malicious agents and environments – Worms, Viruses

PROBLEMS IN THEIR ENVIRONMENT

Unstructured (unknown bounds and density)
Heterogeneous (local languages and rules)
Dynamic changes in data and hazards
Poor quality control (possibly fragile environment)
Hazardous (physical, data, other agents)
Action without human monitoring and evaluation

Note: Contrast with dependability challenges in well-structured environments, eg., aircraft

PROBLEMS IN THEIR REQUIREMENTS

Partial functions with possible empty response
Poor models for multi-agent behavior
End of life may be poorly specified
Formal specification difficult for complex environments and adaptivity
Non-professional design: Service will be easy to prescribe; misbehavior will be hard to visualize

WHAT CAN BE DONE TO IMPROVE DEPENDABILITY?

- Architecture for protecting the environment
  - Protection of resources
  - Constrained environment for agent operation

- Agent integrity
  - Certification of agent candidates
  - Lifetime and renewal limits

- Design for dependability
  - Multi-agent consistency
  - Error detection, diagnosis & recovery
  - Models of group behavior

SOME RESEARCH ISSUES

Cloning
- Safe rules for clone design
- Verify clones before acceptance and launch

Cooperation
- Feasible consistency algorithms for large groups
- Constraints on group behavior

Architecture
- Protected operational environments
- Agent dependability monitors

CONCLUSION

D.E. Dyer, DARPA, CACM, March 1999, pg 53:

(Paraphrasing) Autonomy and partial knowledge make agents attractive, but they can cause problems that may invalidate any advantage for system development. Effective control strategies are essential.

Given the momentum of current work, this warning will probably be ignored.

IFIPS 10.4 has an important contribution to make.

REFERENCES

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Multi-agent Coordination Models for Internet Applications, Computer, Feb. 2000

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Agent links: agents.umbc.edu

Talmud, Tractate Gittin (ca. 100 CE) (Agency in document conveyance)