Towards Self-organizing Bureaucracies

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Goal

• To explore the benefits of using self-organization to improve the efficiency and adaptability of bureaucracies.

• Application of General Methodology to Design and Control Self-organizing Systems
  • http://uk.arxiv.org/abs/nlin.AO/0603045

• Illustrate benefits with Random Agent Networks
  • Novel computational models
Bureaucracies

- Public or private sectors
- e.g. tax collection systems, immigration services, military, educational/academic institutions
- No perfect bureaucracy
- but can always improve

- Obstacles:
  - Rigidity, corruption, delays
- How to measure efficiency of a bureaucracy?
  - Related to the fulfillment of its goals.
Bureaucracies (2)

- Naïve to try to optimize
- Problem space constantly changing
- *Adaptation, anticipation & robustness* are required, self-organization as a method to achieve it.
Previous work

• Cybernetics (Beer, 1966; Cybersyn;...)
• Distributed cognition (Hutchins, 1995;...)
• Organizational learning (March, 1991;...)
• Computational org. theory (Carley & Prietula, 1994)
• Agent Based Modeling (Epstein & Axtell, 1996;...)
• Complexity (Anderson et al., 1999; Lissack 1999;...
Self-organization

● *A Notion*: a system *described* as self-organizing is one in which elements *interact* in order to achieve *dynamically* a global function or behaviour.

- not imposed, nor determined hierarchically
- achieved dynamically as elements interact
- interactions produce feedbacks that regulate the system
Designing S-O.S.

- Organizations as systems of information processing *agents* (Radner, 1993; Van Zandt, 1999; ...)
  - Individuals, departments, ministries, public, etc.
- Agents *act* to achieve *goals*
- “Satisfaction” of agents dependent on goals
- Different goals may lead to conflict
- Minimizing “friction” increases satisfaction of system (Helbing & Vicsek, 1999)
Designing S-O.S. (2)

• Synergy as negative friction
• *Mediators* (Heylighen, 2003) to constrain and promote behaviours: min friction & max synergy
  • How to do it? See Methodology...
• Need simulations
  • Cannot predict system, feedback with practice
A Self-organizing Bureaucracy

• Elements are expected to *dynamically* and *autonomously* solve a problem or perform a function at the system level.
The Role of Communication

• Synchronous
  ◦ Verbal, phone, video, IRC
  ◦ Quick, but needs coordination of agents

• Asynchronous
  ◦ Post, telegraph, telex, fax, IM
  ◦ Delayed, but no coordination
  ◦ Technology has reduced delays...
Delays as Friction
Response delay

- E-media reduce transmission delays
- But also their logs can be analysed to restructure SOBs:
  - Logs show efficiency, workload, and visualization of agents and their interactions
Decision delays

• Technology also reduces them
• E-decision-makers
• Negotiation, trust, reputation facilitate coordination
• E-government
• Computer-aided decision-making
• “Cognitive Stigmergy” (Ricci et al., 2006)
The Role of Sensors

- Public as environment of bureaucracies
- Need good sensors to make good decisions
- Complex sensors “digest” relevant information
- Public participation slow and difficult
  - e.g. polls
Public satisfaction as efficiency

• Low satisfaction = friction
• How to measure without public participation?
  • Public attention delay
    ▪ Waiting delay + processing delay
• Frequency of interaction

• Public and bureaucracy will be satisfied if delays and interactions are minimized
• Automatically detect bottlenecks
The Role of Hierarchies

- Useful, but rigid
- Requisite variety
  - (Ashby, 1956)
- Requisite hierarchy
  - (Aulin, 1979; ...)
- Hierarchies as networks
  - (Newman, 2003; ...)
Adapting networks

- a) Hierarchy
- b) Add interactions
- c) Modules
- d) Shortcuts
- Small-world
  - (Bollen & Heylighen)
The Role of Context

• Not every agent needs/has same information
• Uniform approaches create friction
• *Contextualize* interactions to provide/request ad hoc information
  • e.g. Personalize tax forms
• Automatically categorize co-occurring contexts
A Toy Model: Random Agent Networks

- Inspired partly by random Boolean nets
  *(Kauffman, 1969; Gershenson, 2004;...)*
- $N$ nodes (agents) solving tasks
- Each with $K_i$ dependencies, chosen randomly
- Task complete once requests from all dependencies are answered
- Dependencies keep tasks in FIFO queue
- For simplicity, dependencies don't propagate
Random Agent Networks (2)

• Time abstracted: 1 timestep for:
  • Send requests to dependencies (transmission delay)
  • Answer 1 request from queue (decision delay)
  • Integrate requests and complete task (decision delay)

• Performance of net as #tasks completed
  • Minimize response delay and idling time (empty queues)
  • Balance tasks request and response

• Sequential updating (deterministic)
Topologies

- Homogeneous
  - Every agent has \textit{exactly} $K$ (random) dependencies

- Normal
  - Each agent has $K$ (random) dependencies \textit{on average}

- Scale-free
  - Few with a lot, most with a few: $P(x) = (\gamma - 1)x^{-\gamma}$

- Symmetric
  - Non-random, agent depends on $K$ neighbours (CA-like)
RANLab

- [http://rans.sourceforge.net](http://rans.sourceforge.net)
- e.g. $N = 25$, $K = 5$, homogeneous topology.
- a) Response delays. b) Queue lengths.
- Lighter colours indicate higher values.
Self-organize!

- Long queues = friction → try to reduce them
Simulation results

• Normalize topologies to have similar number of dependencies
• 1000 nets generated for each case & topology
• plot response rate (avg. tasks completed / timestep) each time self-organization is applied
• (each 1000 timesteps)
$N=15, \ K=1$
$N=15$, $K=2$
$N=15, K=5$
$N=15$, $K=15$
$N=100, K=1$
$N=100, K=5$
$N=100, K=100$

(25 nets)
RAN Discussion

• Many open questions, but illustrates the benefit of self-organization in bureaucracies
• Showed that only few modifications on random networks lead to near optimality
  • Model doesn't take cost into account...
• RANs self-adaptive to changes in demands
• Weights can model diversity of delays
Future Work

• Study RAN robustness (damage of nodes)
• Phase transitions? (order/chaos)
• Refine model to make more realistic
  • e.g. Include costs
  • Domain expertise
• Possible implementation?
Conclusions

- Presented different ways in which self-organization can improve bureaucracy efficiency
  - Decrease delays → reduce friction
- Adaptability and robustness
  - Speed of reaction and decision will allow adaptation while preserving functionality
- Similar ideas could be used in different organizations