DELIS

Dynamically Evolving, Large-scale Information Systems

Choose Your Tribe!
Evolution at the next level in P2P network

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Information Society Technologies

The Basic Problem

- Consider a P2P overlay network in which each node:
  - Offers a service (e.g. storage, processing etc.)
  - Receives jobs submitted by users
  - May ask neighbour nodes to help complete jobs
  - May complete jobs for neighbours
  - May move in the network by making and breaking links
  - Uses local information only
  - Behaves in a selfish way (boundedly rational)
  - May compare its performance to other nodes
  - May copy links, and behaviours of other nodes
- We want a scalable, robust, light-weight decentralised algorithm that self-organises network to maximise system level performance

The Solution - The SLAC algorithm

- SLAC = Selfish Link-based Adaptation for Cooperation
- Demonstrated to be effective in P2P networks when:
  - Peers play the Prisoner's Dilemma with neighbours (ESOA'04)
  - Peers answer queries and share files (IEEE TSMC'05)
- But in these previous scenarios:
  - Nodes provided an identical service
  - Cooperation resulted from all nodes behaving identically
- This new problem requires specialists nodes to work together
- In order to maximise system level performance nodes need to do different things, not identical things
- This work therefore tests if SLAC can support inter-node specialisation

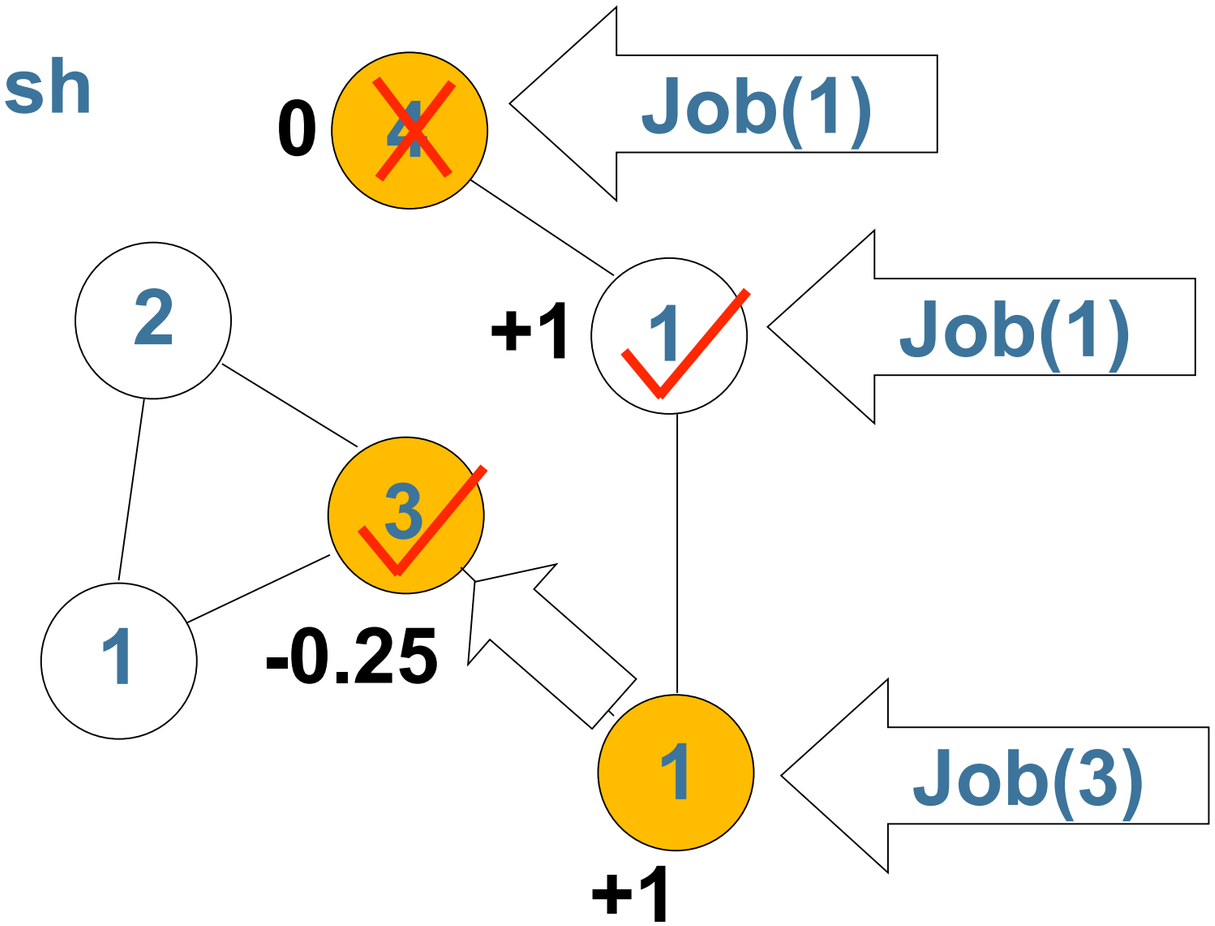
The Simulation - SkillWorld

- To test this produced a simulation model called SkillWorld
- The population consists of N nodes (fixed)
- Each node has the following state:
  - A single skill from a set S ∈ {1,2,3,4,5} (the service provided)
  - An altruism flag A ∈ {0,1} (indicates if node helps neighbours)
  - A utility U ∈ R (a performance measure)
  - Some set of links to other nodes (max. of 20)
- Each node asynchronously receives and attempts to complete jobs
  - Each job is marked with a single skill # (randomly chosen)
  - Job must be processed by a node with matching skill
  - If receiving node i has req. skill, job is completed Ui = Ui + 1
  - If node i does not have req. skill it asks its neighbours
  - If a neighbour j is found with A = 1 and matching skill then:
  - Job is completed, Ui = Ui +1, but, Uj = Uj - 0.25

The Simulation - SkillWorld

= altruist

= selfish



The SLAC algorithm

- SLAC follows a kind of evolutionary process
- Periodically each node:
  - Engages in application level activity producing utility (SkillWorld)
  - Compares its utility to another randomly chosen node
  - If the other node has higher utility then
  - Copy links and some behaviour of other node
  - With low probability “mutate” links and behaviour

The SLAC algorithm in SkillWorld

Active thread:	Passive thread:

do forever:
sleep for some short time period
i ← this node
with prob. P reproduce:
  j ← SelectRandomNode()
  j.GetState(i)
  if i.Utility ≤ j.Utility
  i ← CopyStatePartial(j)
  Mutate(i)
	do forever:
	j ← this node
	GetState(i):
	  Send j.Utility to i
	  Send j.Links to i
	  Send j.AltruismFlag to i

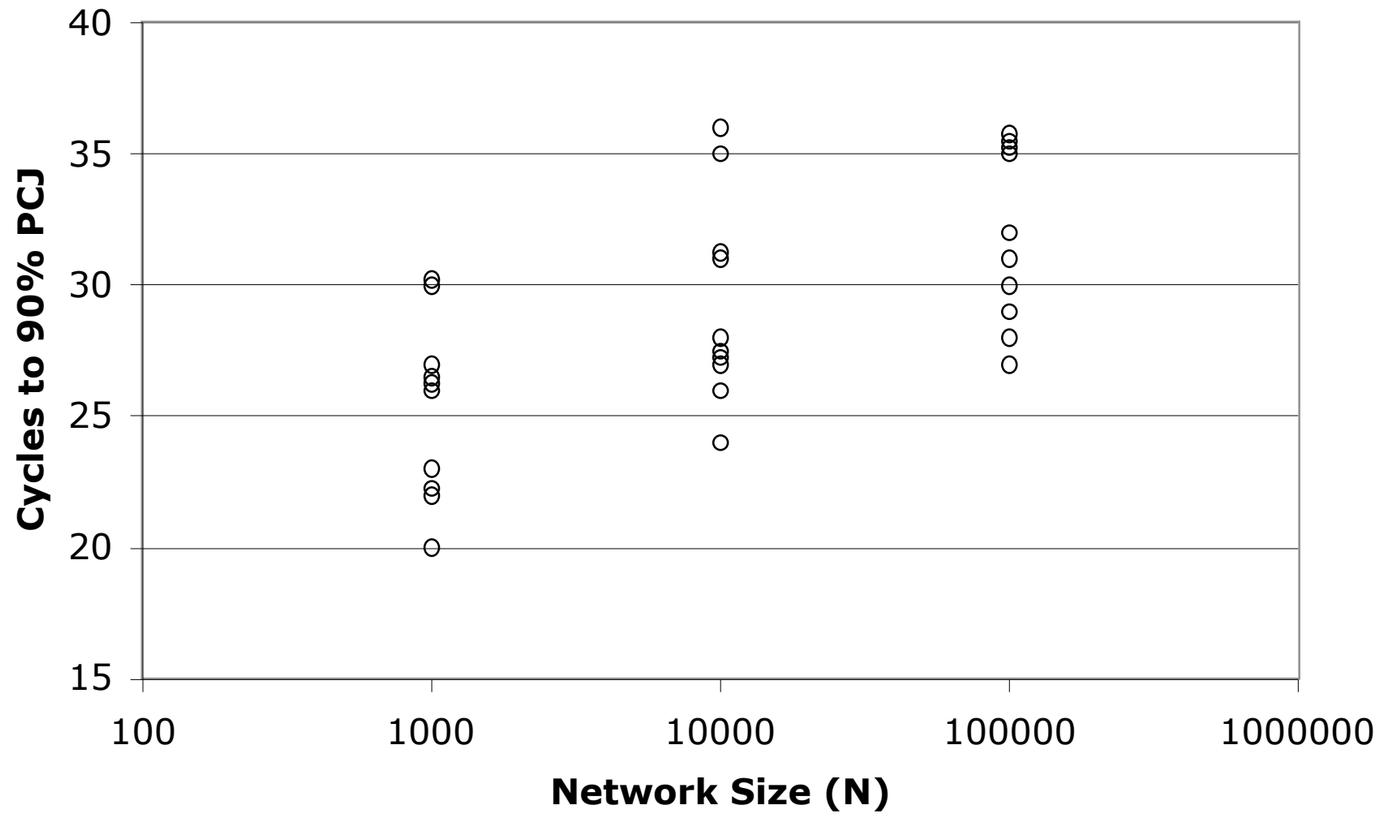
Function CopyStatePartial(j):	**Function Mutate(i):**

i.AltruismFlag ← j.AltruismFlag
drop all links from i
i.Links ← j.Links
	with prob. M mutate i.AltruismFlag
	with prob. MR mutate i.Links:
	  drop all links from i
	  i.Links ← SelectRandomNode()

SkillWorld simulation specifics

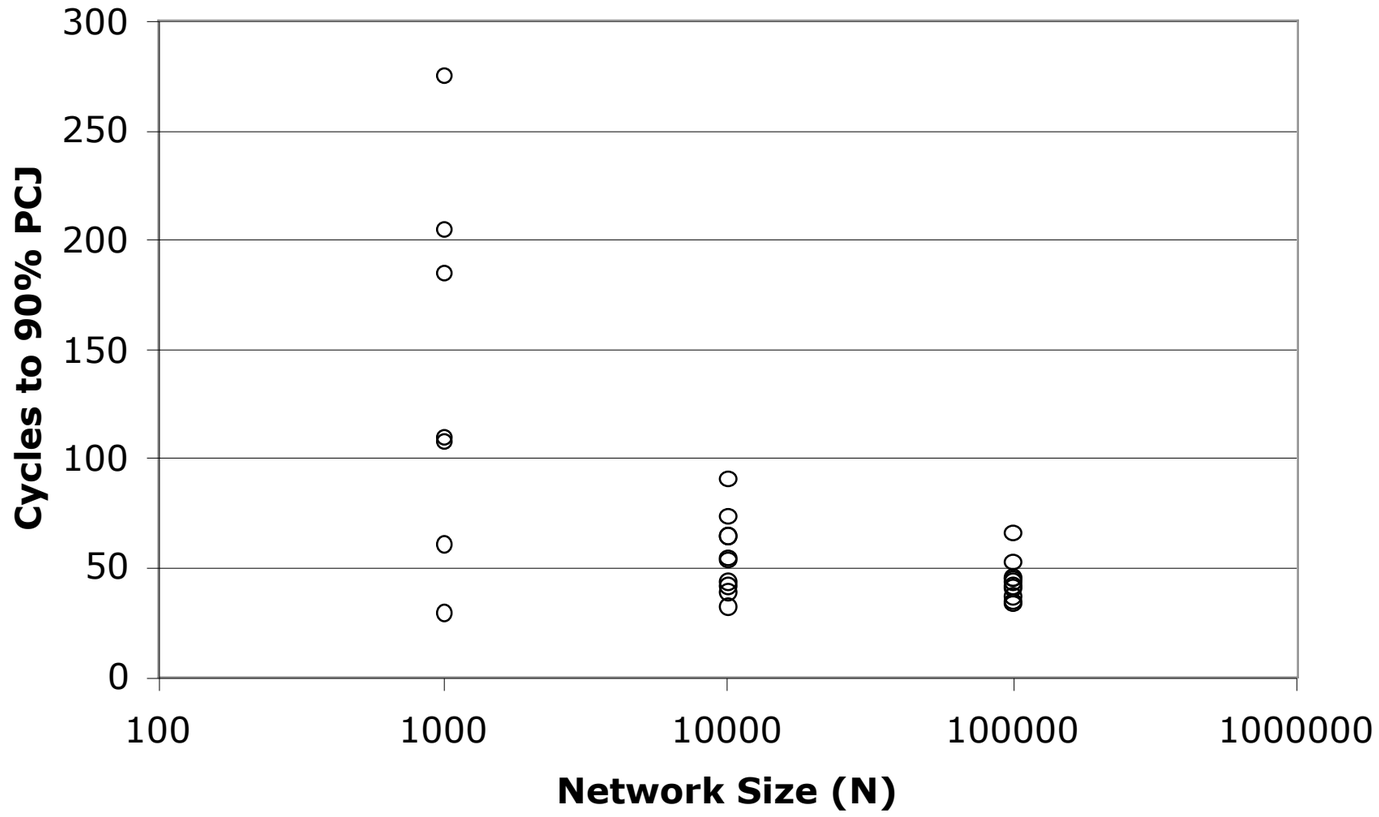
- In each cycle, 10N jobs are submitted to randomly selected nodes
- Each job is given a randomly selected skill requirement
- Nodes initialised with random skills and links (random network)
- Initial topology of network made little difference to results
- Compared initialisation of altruism flag randomly and all selfish
- Compared different network sizes N
- Measured proportion of completed jobs (CJ) in each cycle
- Mutation values (M = 0.001, MR = 0.01)
- If a node reaches its max. links (20) then a random link is discarded if a new link is required
- Utility for each node = CJ - total help cost
- Ran simulations until 90% of jobs completed

Simulation Results



Number of cycles to high performance for different N
When PCJ > 90% over 90% of all jobs submitted to nodes are completed.
Nodes are initialised at random

Simulation Results



Number of cycles to high performance *when all nodes are initialised selfish*
Note that there is a reverse scaling cost here.

Simulation Results

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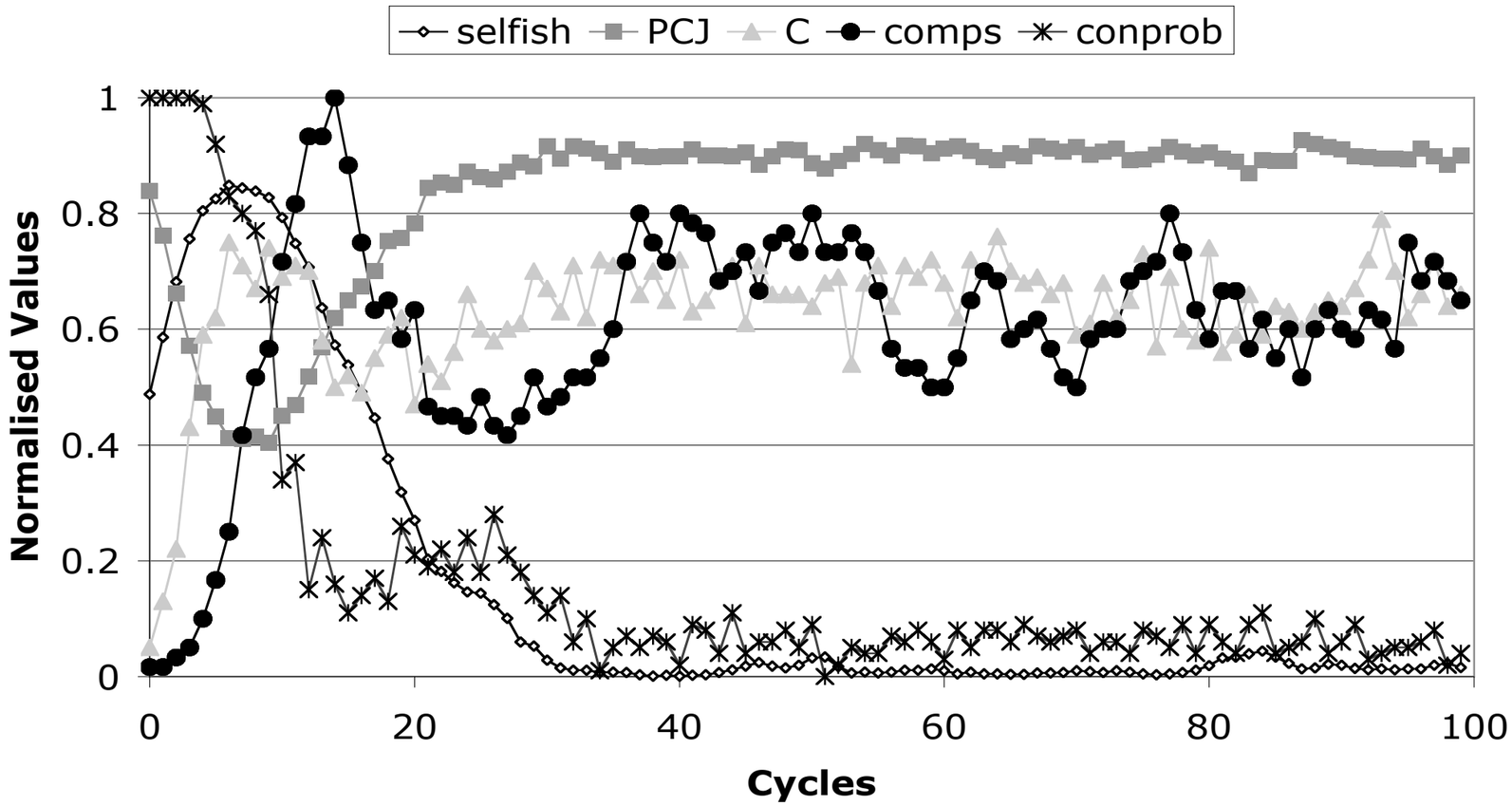

Typical single run (N=1000) from random initialisation.
selfish = proportion non-altruists, C = clustering coefficient,
comps = components in the population (normalised by dividing by 60),
conprob = average probability that a route exists between any two nodes.

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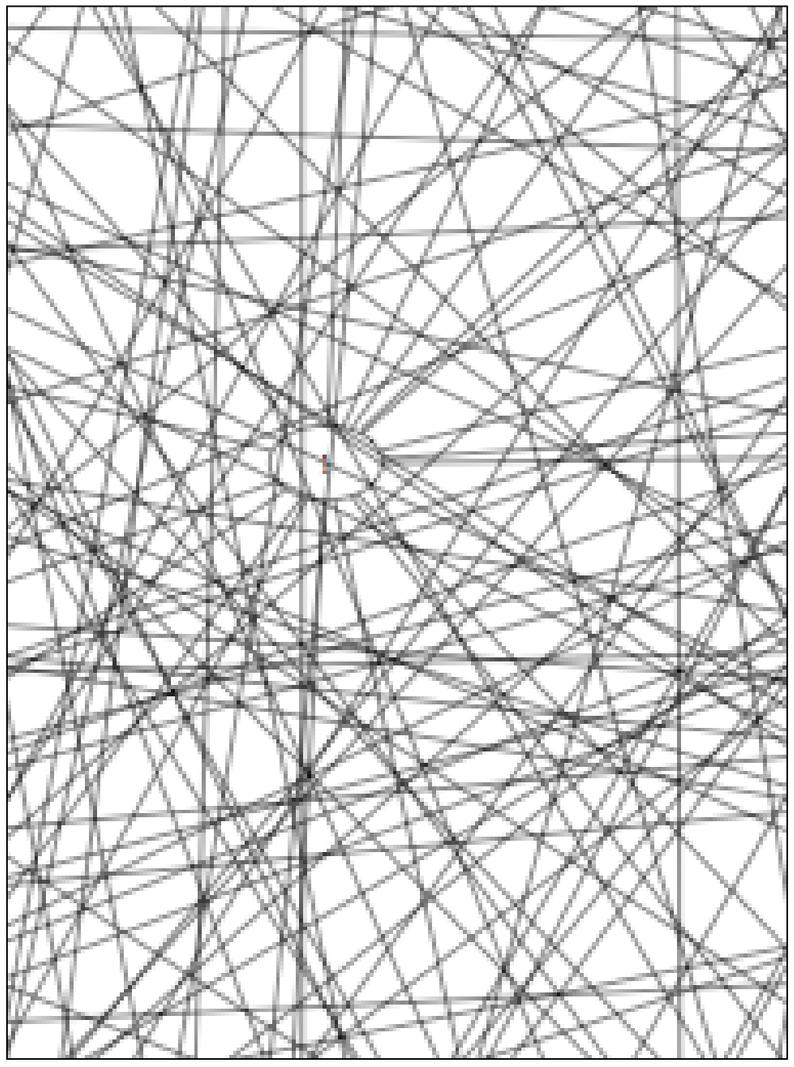
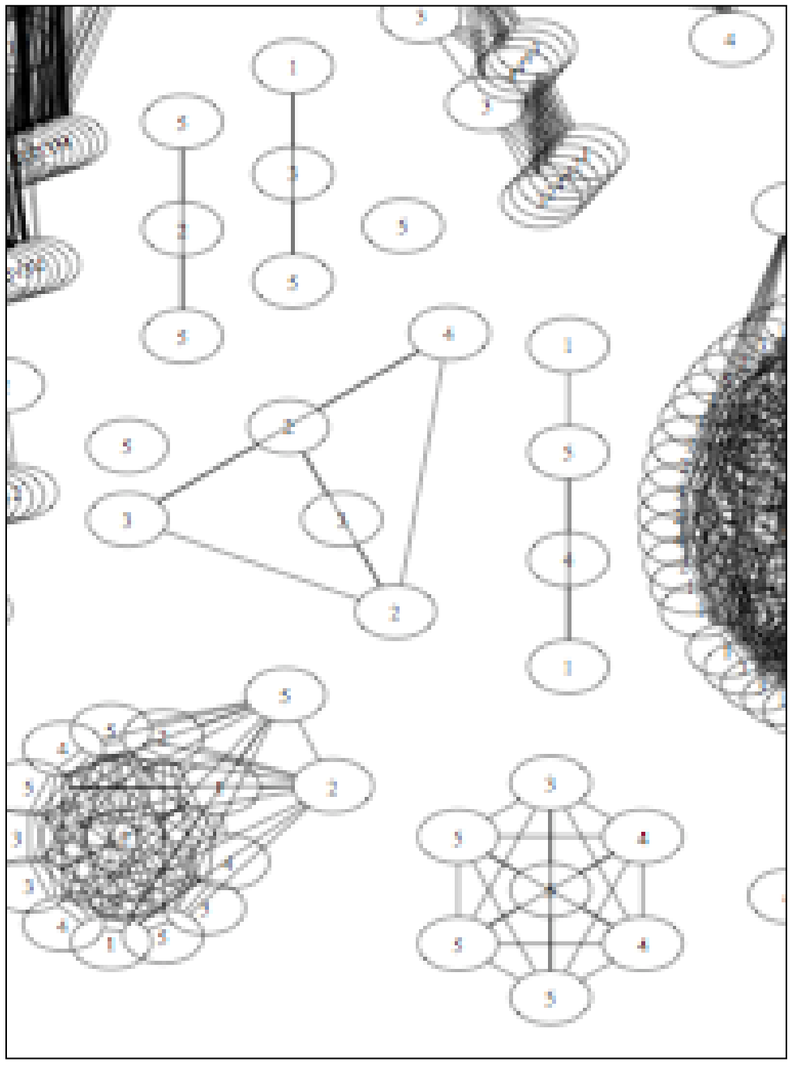


Cycle 0



Cycle 10

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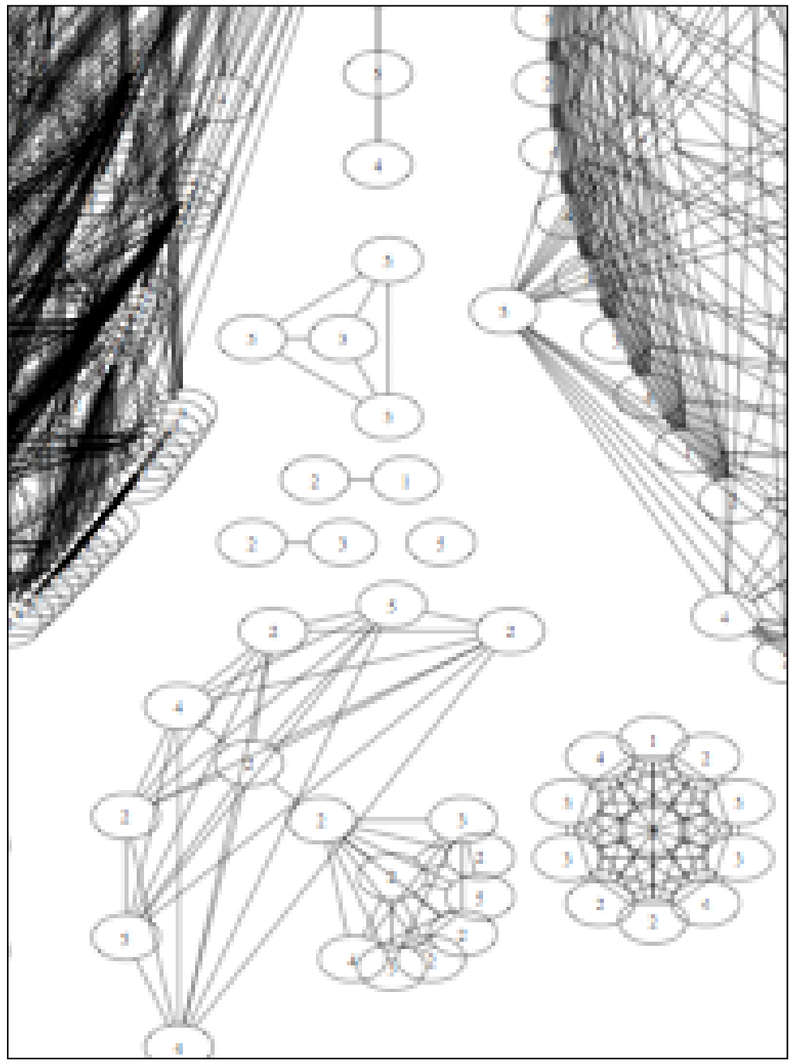
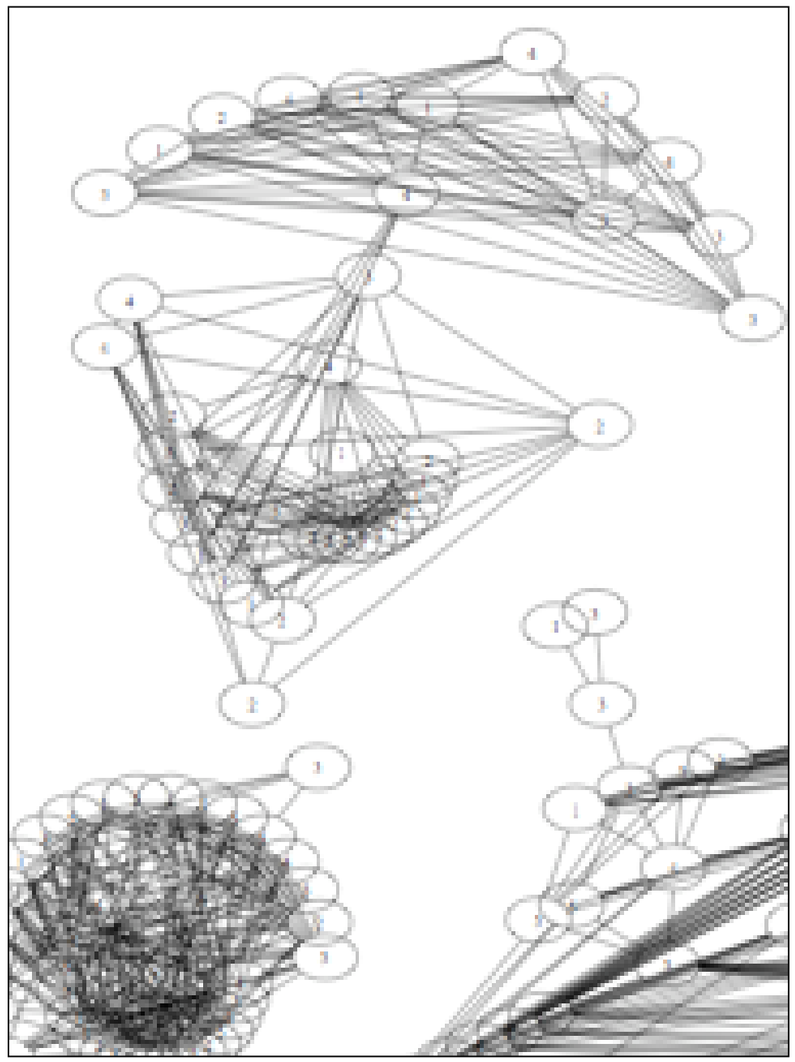


Cycle 20



Cycle 30

Simulation Results Summary

- From individual bounded utility maximising behaviour (SLAC)
- Altruistic “tribes” emerge with internal specialisation
- Tribes that do well - collectively - tend to recruit new nodes
- Tribes that perform badly - collectively - tend to lose nodes
- Hence productive tribes prosper, defective tribes “die”
- This is a kind of “tribe selection” via recruitment and retention
- By giving nodes the ability to choose their tribes a kind of tribe level evolution happens - evolution at the next level

Issues, on-going and future work

- But SLAC produces extreme tribalism with disconnected components => SLACER (on-going work)
- SLAC assums honest passing of info and utility comparison => Greedy Cheating Liars (on-going work)
- The SkillWorld task is an “easy” test => more realistic scenarios
- System performance does not attain more than about 93%
- If Skill mutated then can adjust to different job task loadings
- But if Skill is copied like the AltruismFlag then fails to converge, yet in similar scenarios it does
- Tribe recruitment is the key idea => (on-going work)
- Future work could drop utilities and move to satisficing where aspiration level is a kind of “required service level”

Conclusions