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Centralisation *vs* Self-Synchronisation:

An Agent-Based Investigation

Tony Dekker, DSTO Australia

11TH ICCRTS — 2006

COALITION C2 IN THE NETWORKED ERA

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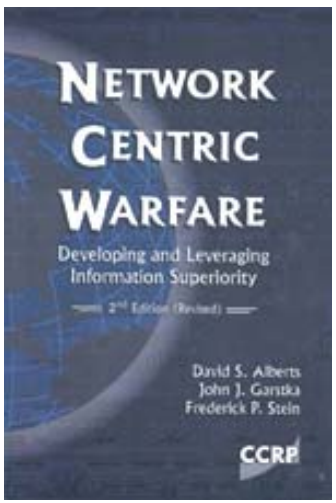
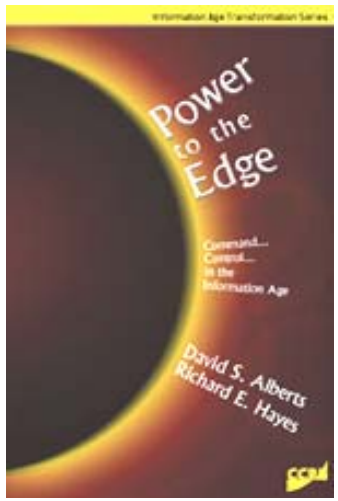
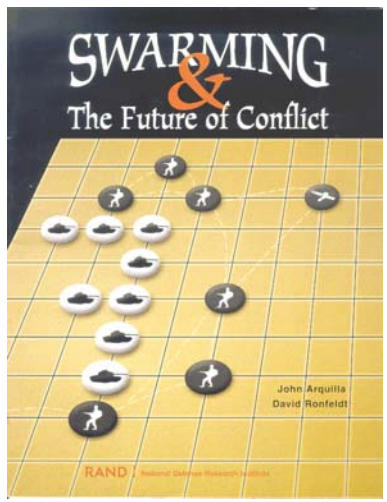
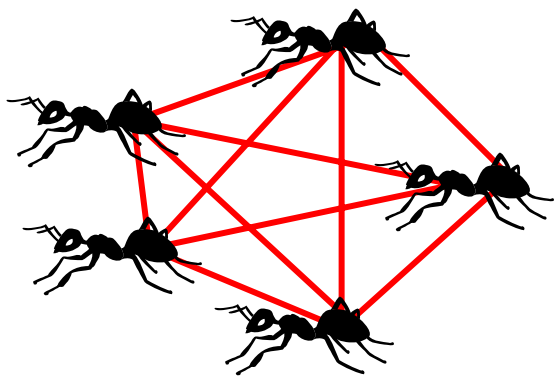
Why Centralisation *vs* Self-Synchronisation?

- Much literature suggests self-synchronisation is good
- But **when** is self-synchronisation good?
- When is centralisation better?
- Will depend on **problem**, on **time pressure**, and on **network**









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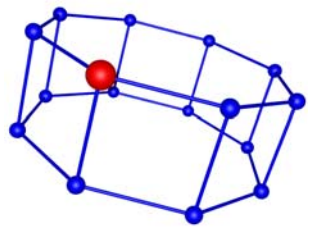
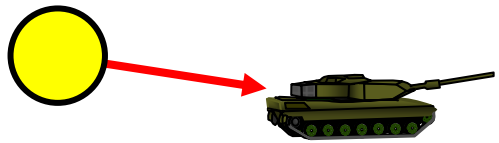
Outline of the Talk

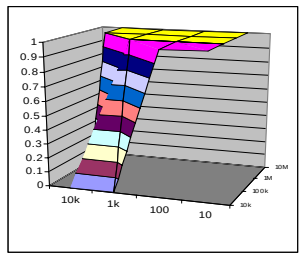
1. Centralised vs Self-Synchronised networks



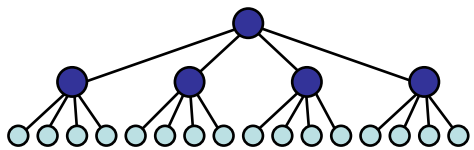
2. The Target Assignment Problem



3. Experimental Results



4. What about Hierarchies?



5. Conclusions

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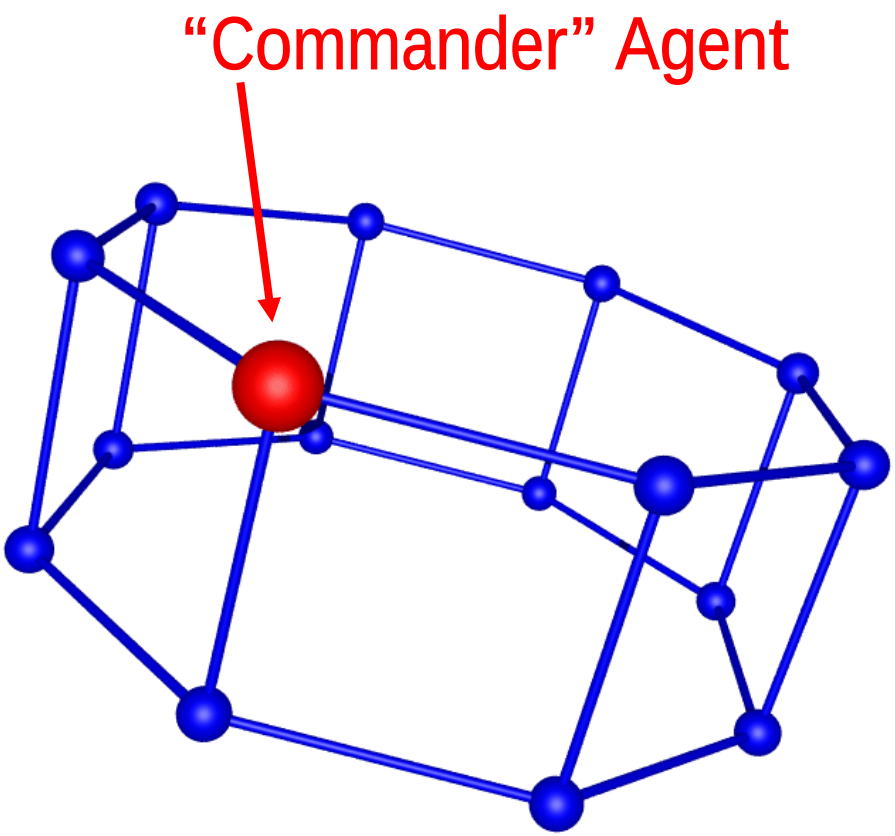
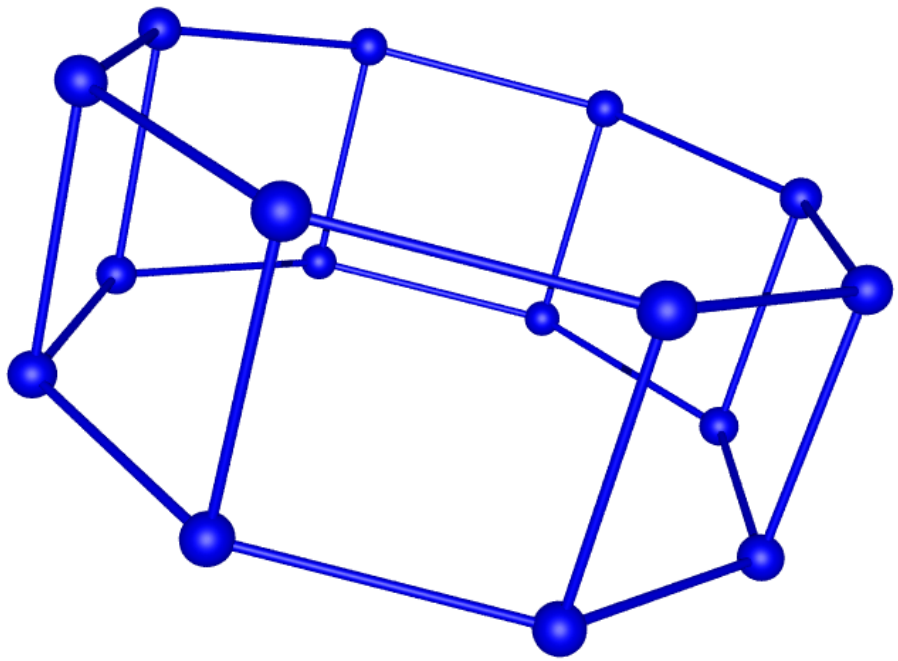
Centralised *vs* Self-Synchronised Networks



Centralised



Self-Synchronised (Distributed)

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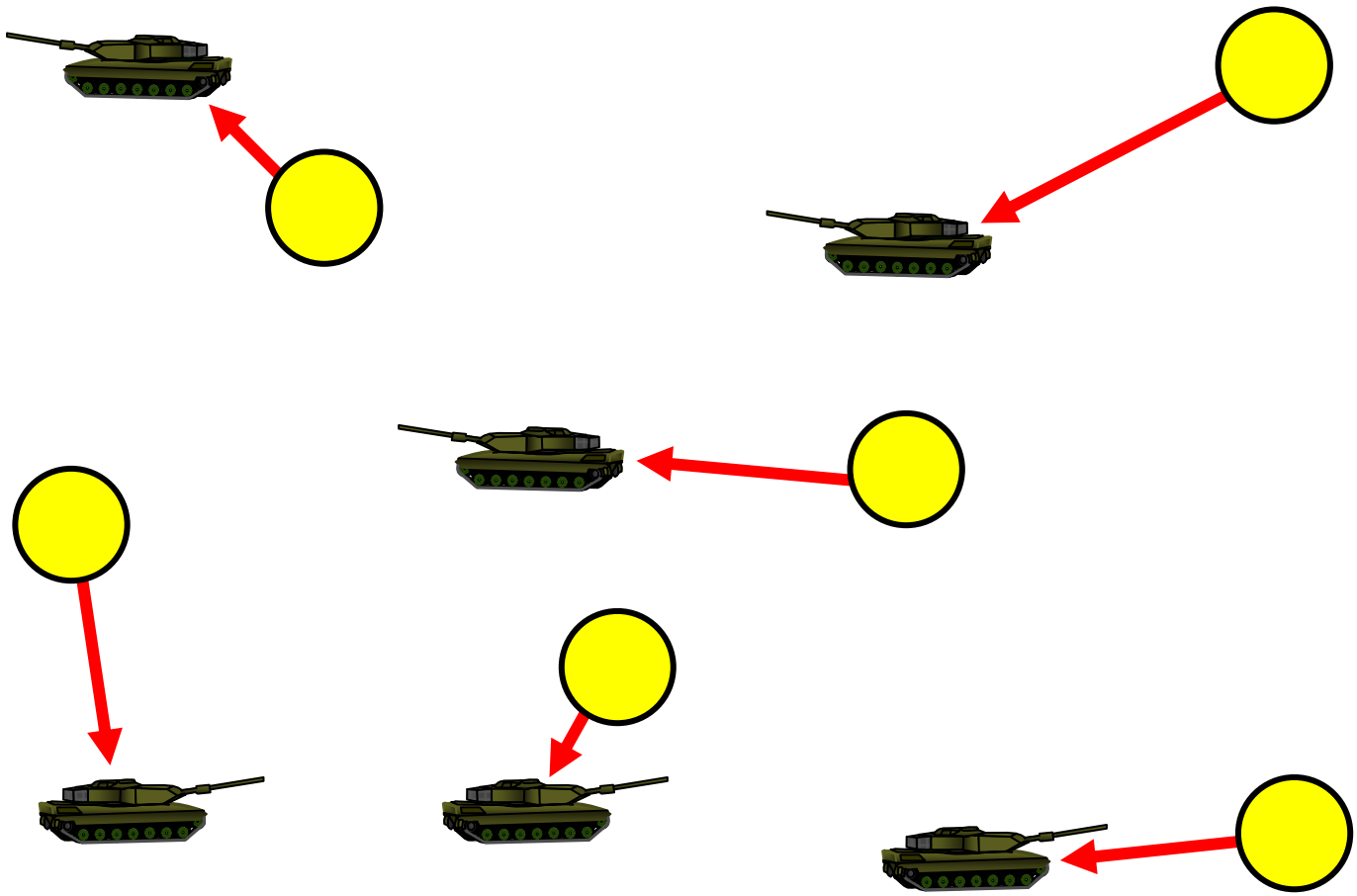
The Target Assignment Problem

Problem: Find Best Agent/Target Match
(compare against theoretical best solution)



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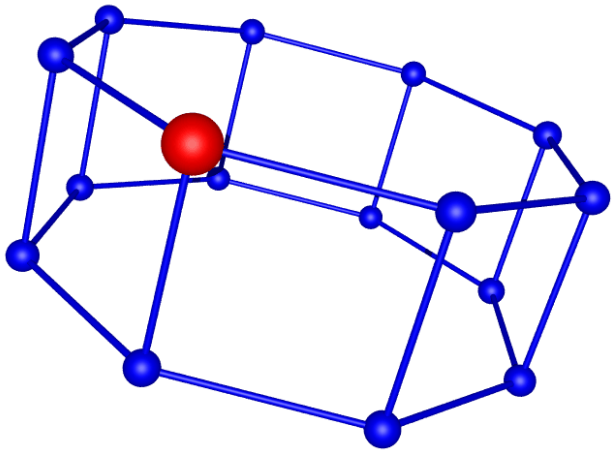
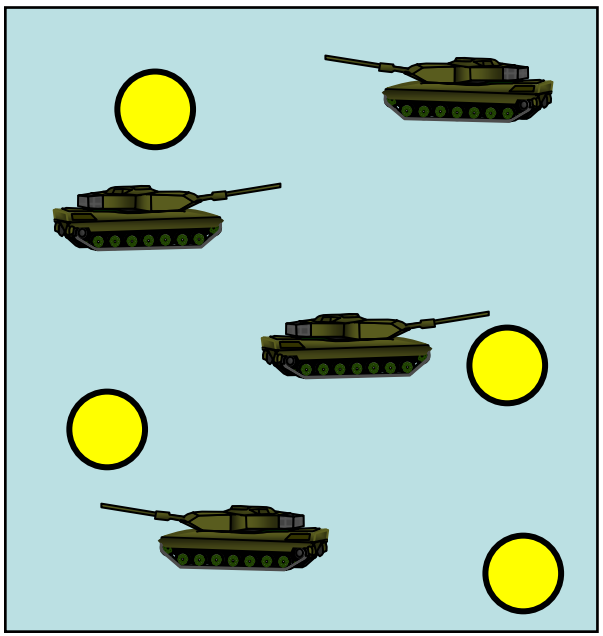
Centralised Approach





1. Each agent sends position information to the “Commander” agent.
2. “Commander” agent finds the best possible solution, given the available time (choice of methods)
3. “Commander” agent broadcasts its decision to the other agents
4. Try with 16 and 64 agents

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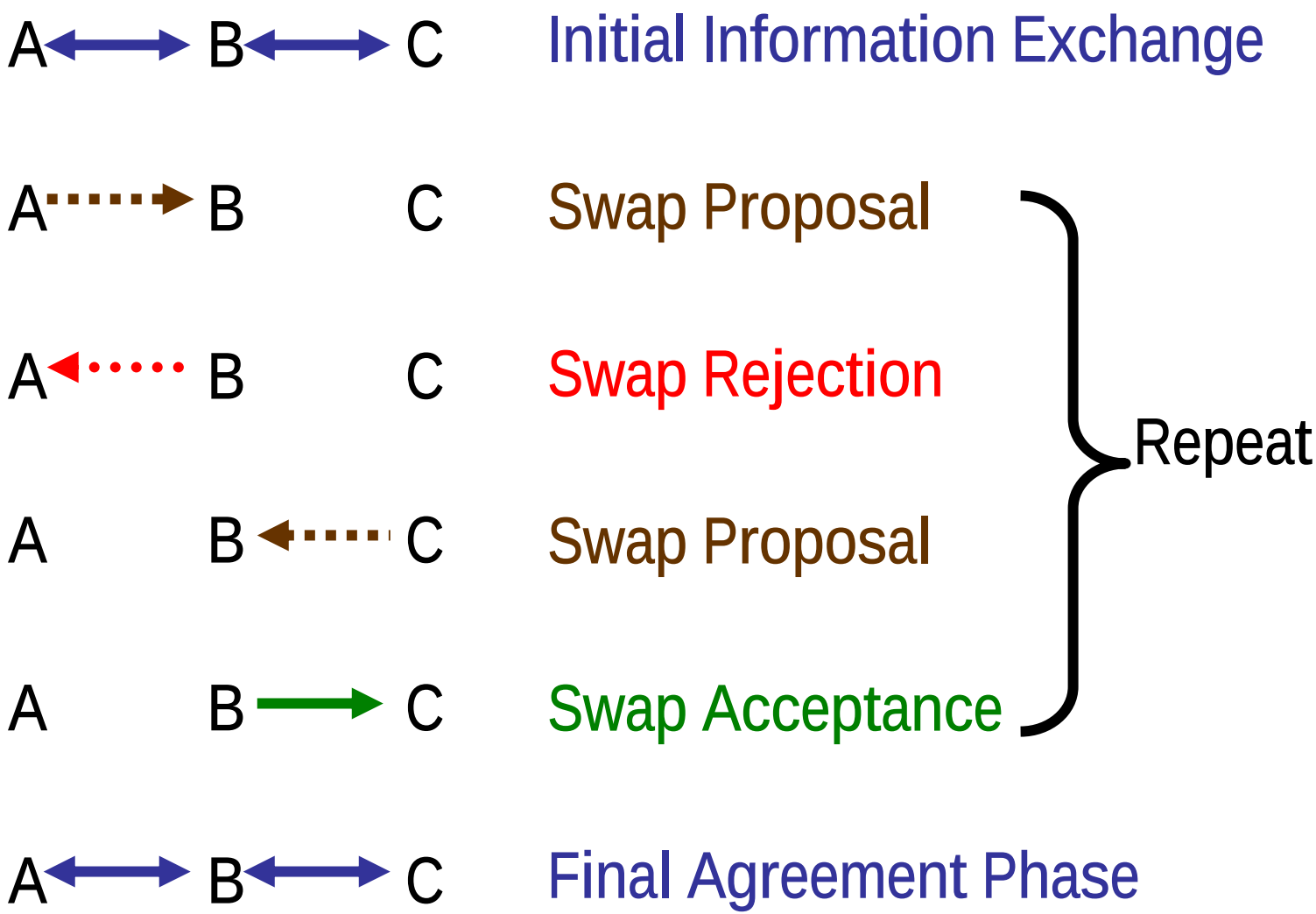
Self-Synchronisation by "Mission Swapping"



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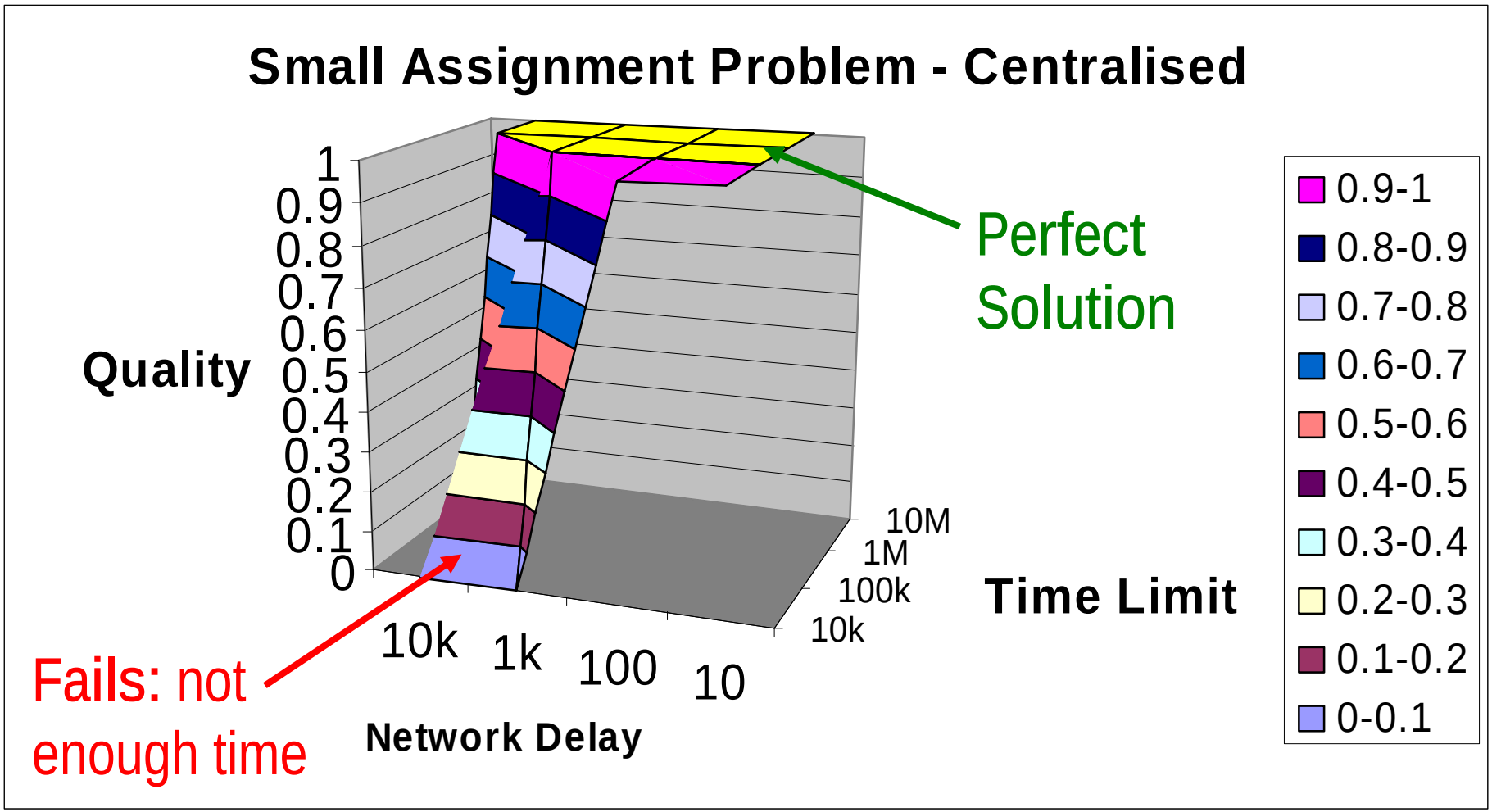
Centralised Approach with 16 Agents



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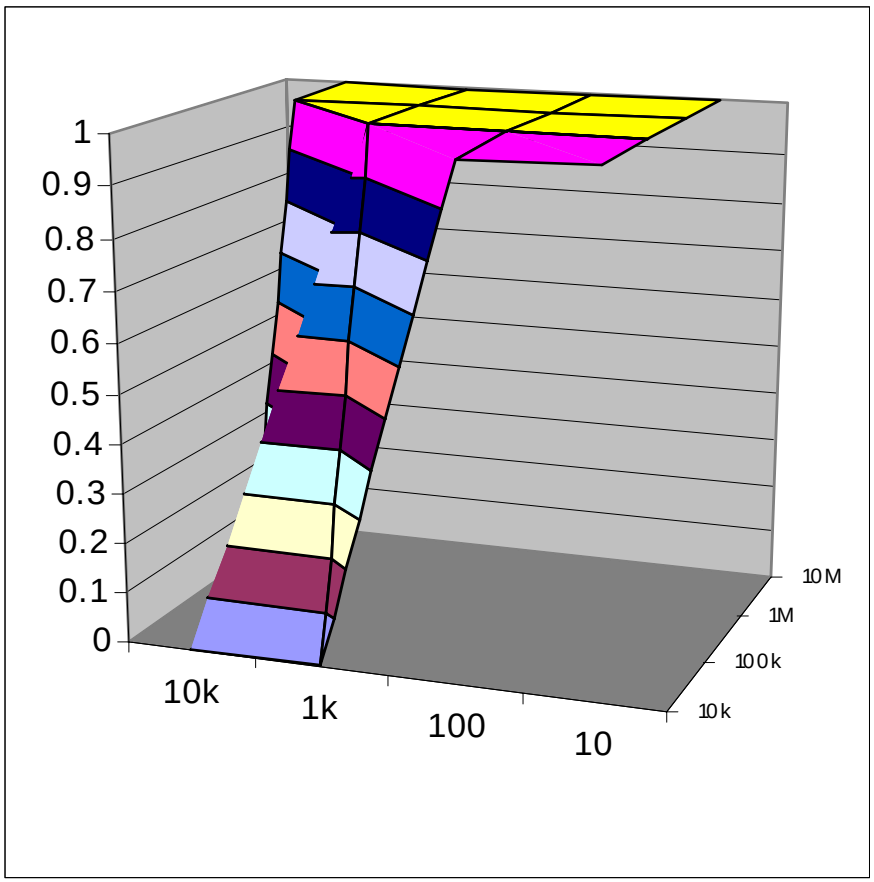
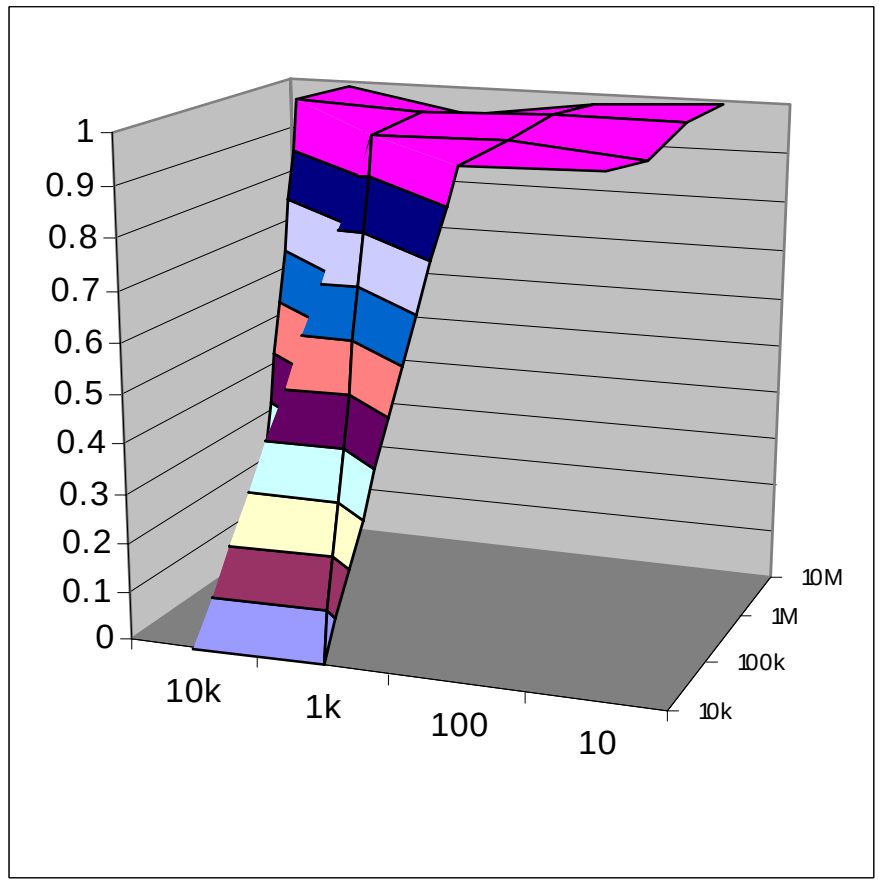
For 16 agents, Centralised is Best

Centralised



Self-Synchronised



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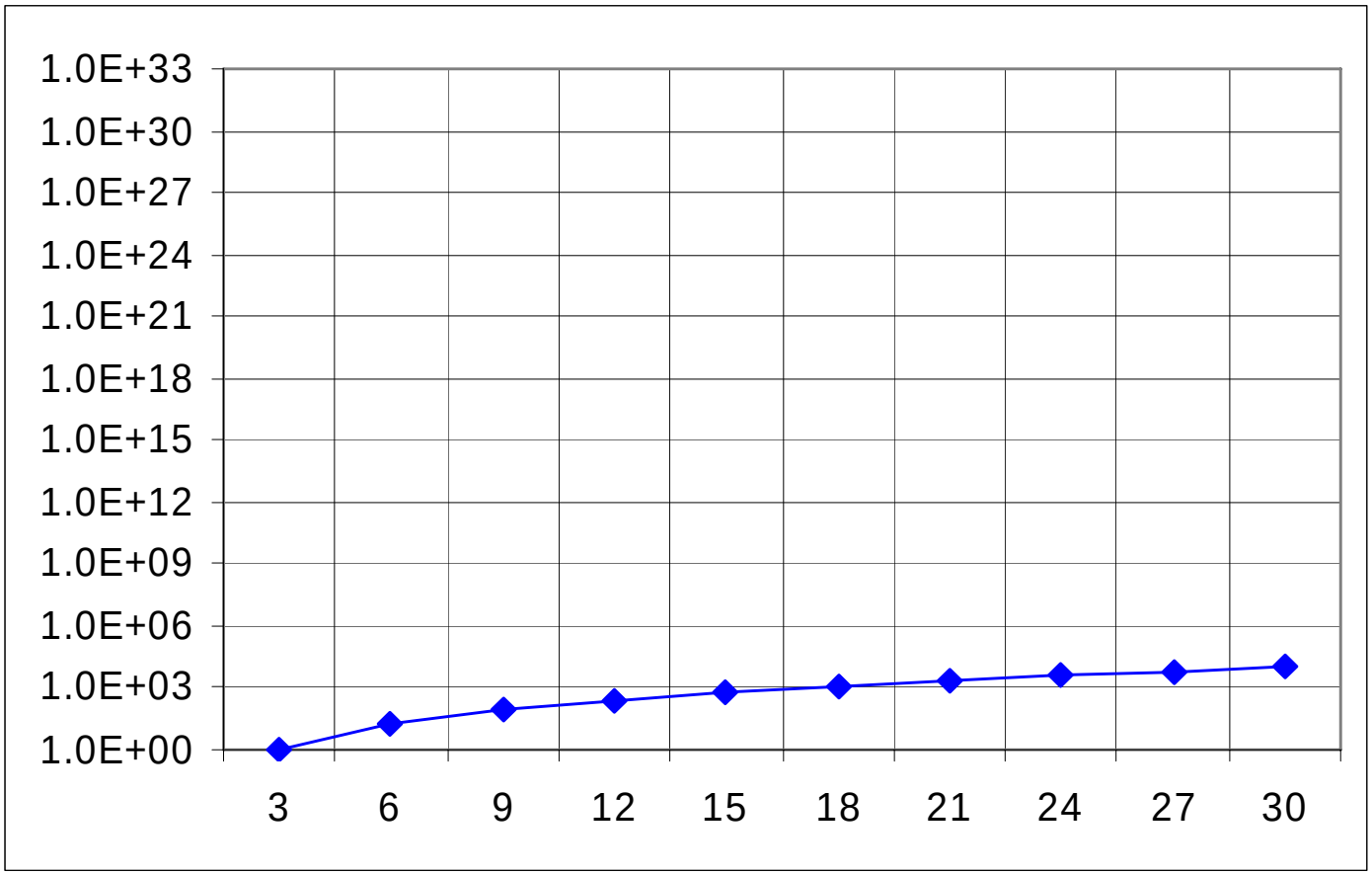
Easy vs Hard Problems

For Target Assignment, problem becomes more difficult with more agents (n^3 or n^4 time)



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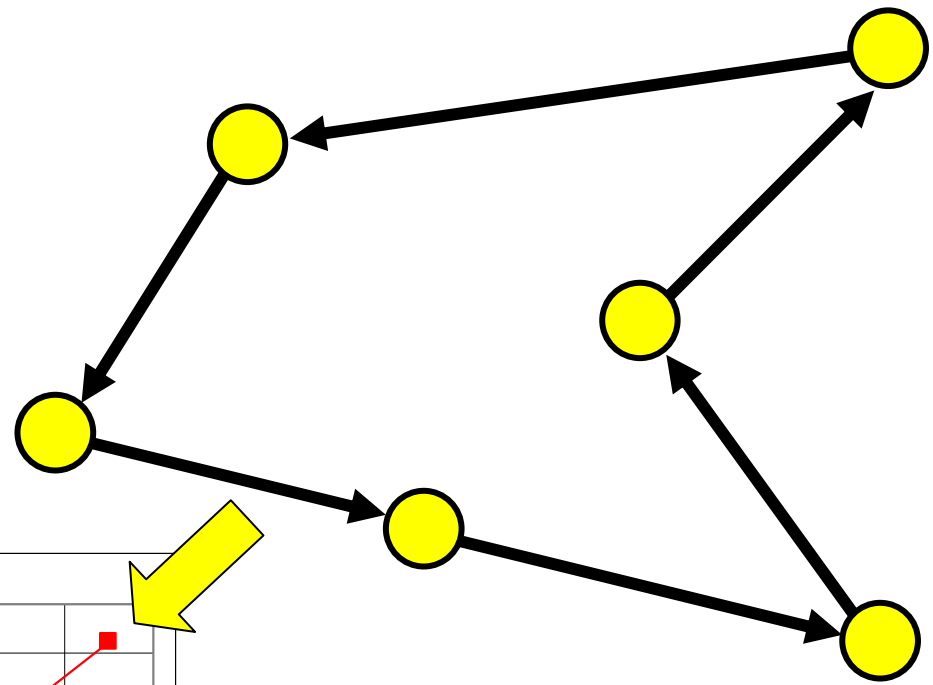
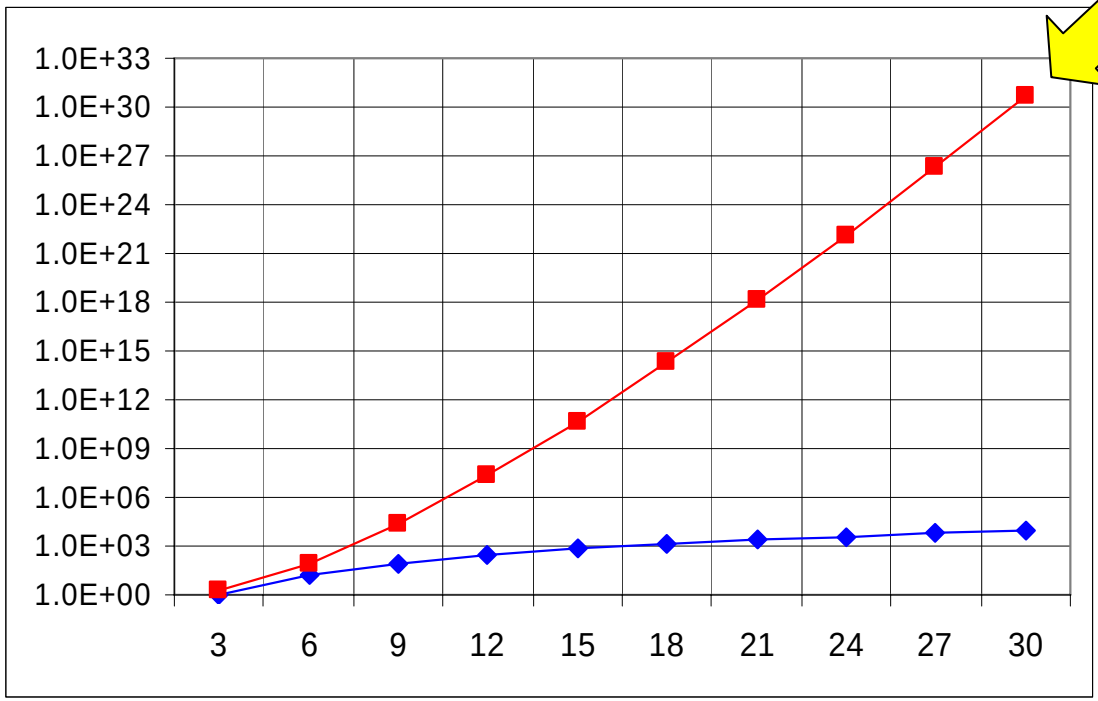
"Travelling General"– exponential difficulty





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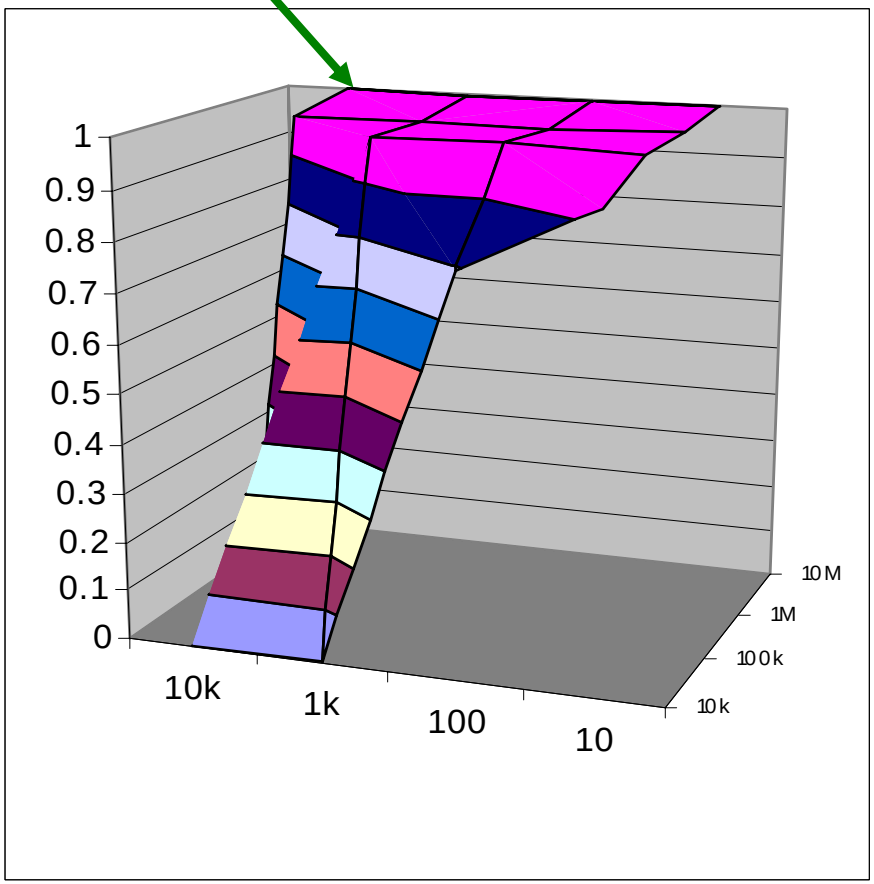
Target Assignment with 64 agents

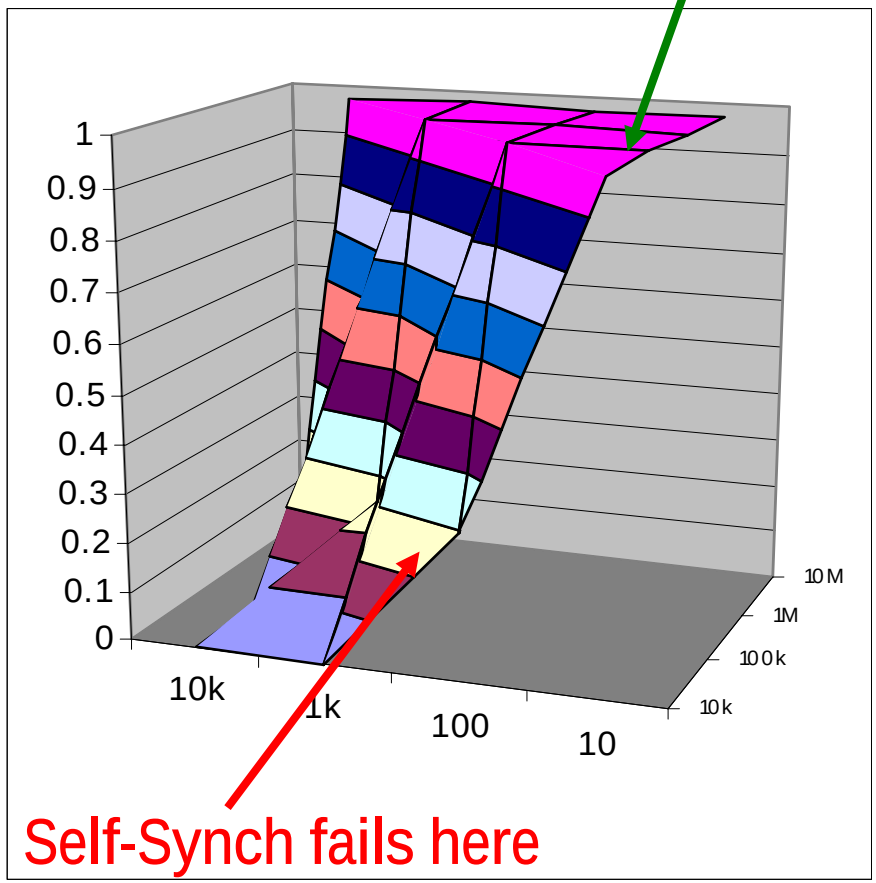
Perfect answer for relaxed time limit

Self-Synch. best for tight time limit & fast net

Centralised



Self-Synchronised



Self-Synch fails here

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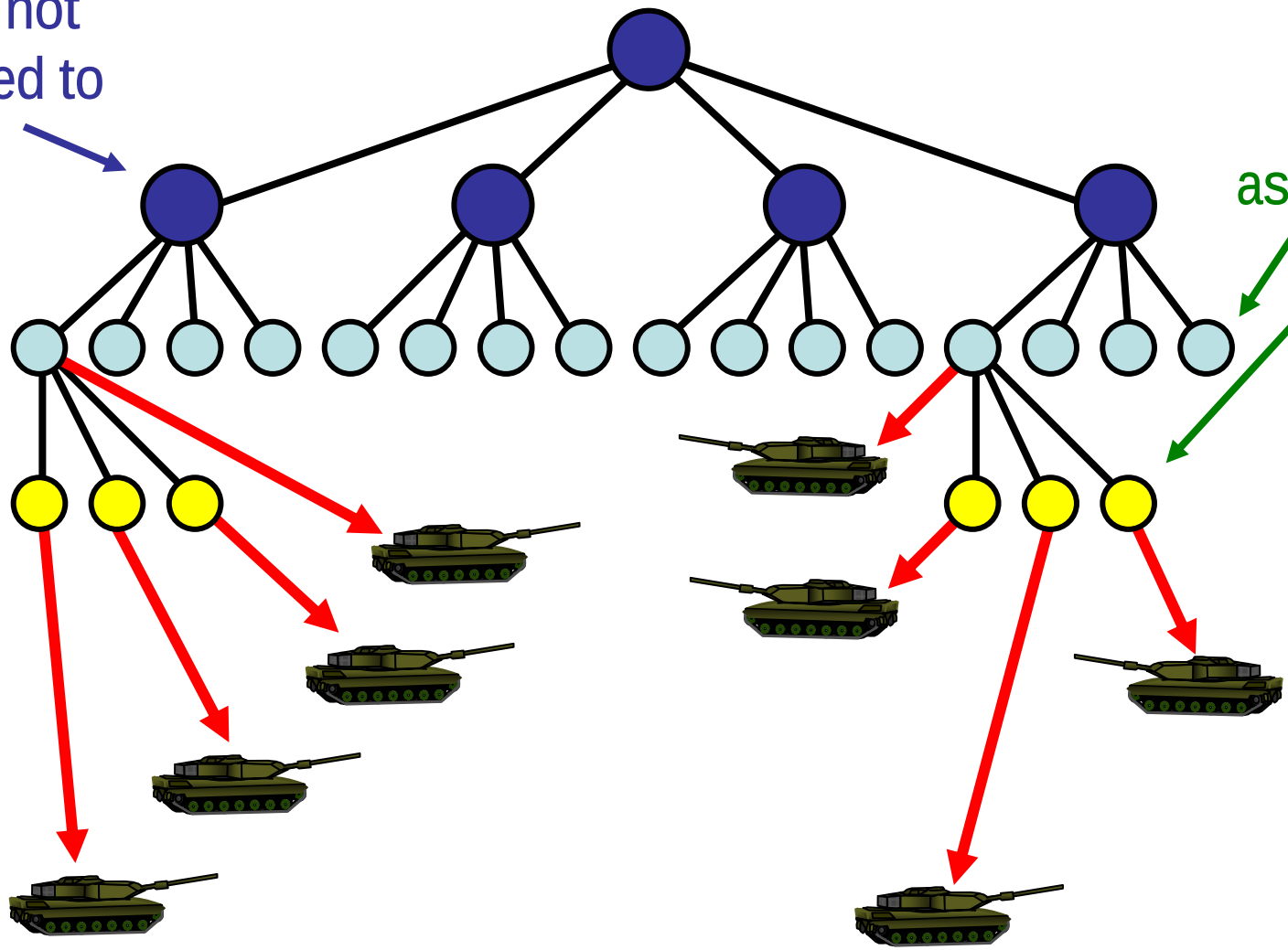
What about Hierarchies?

Tree structure for C2 and for network

5 "Command" agents not assigned to targets



64 assignable agents

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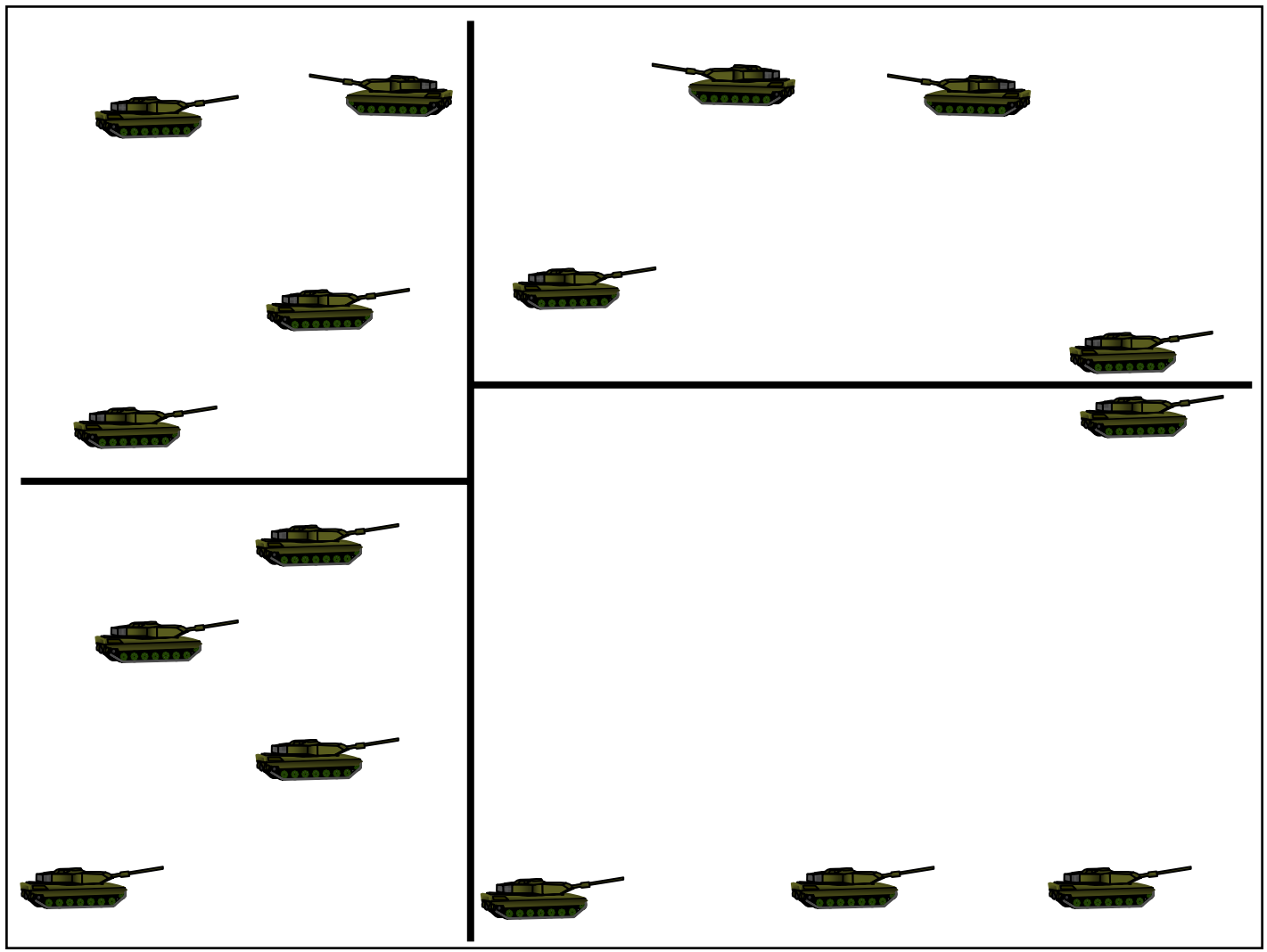
"Divide and Conquer" with Hierarchies

Subdivide the problem into easier sub-problems



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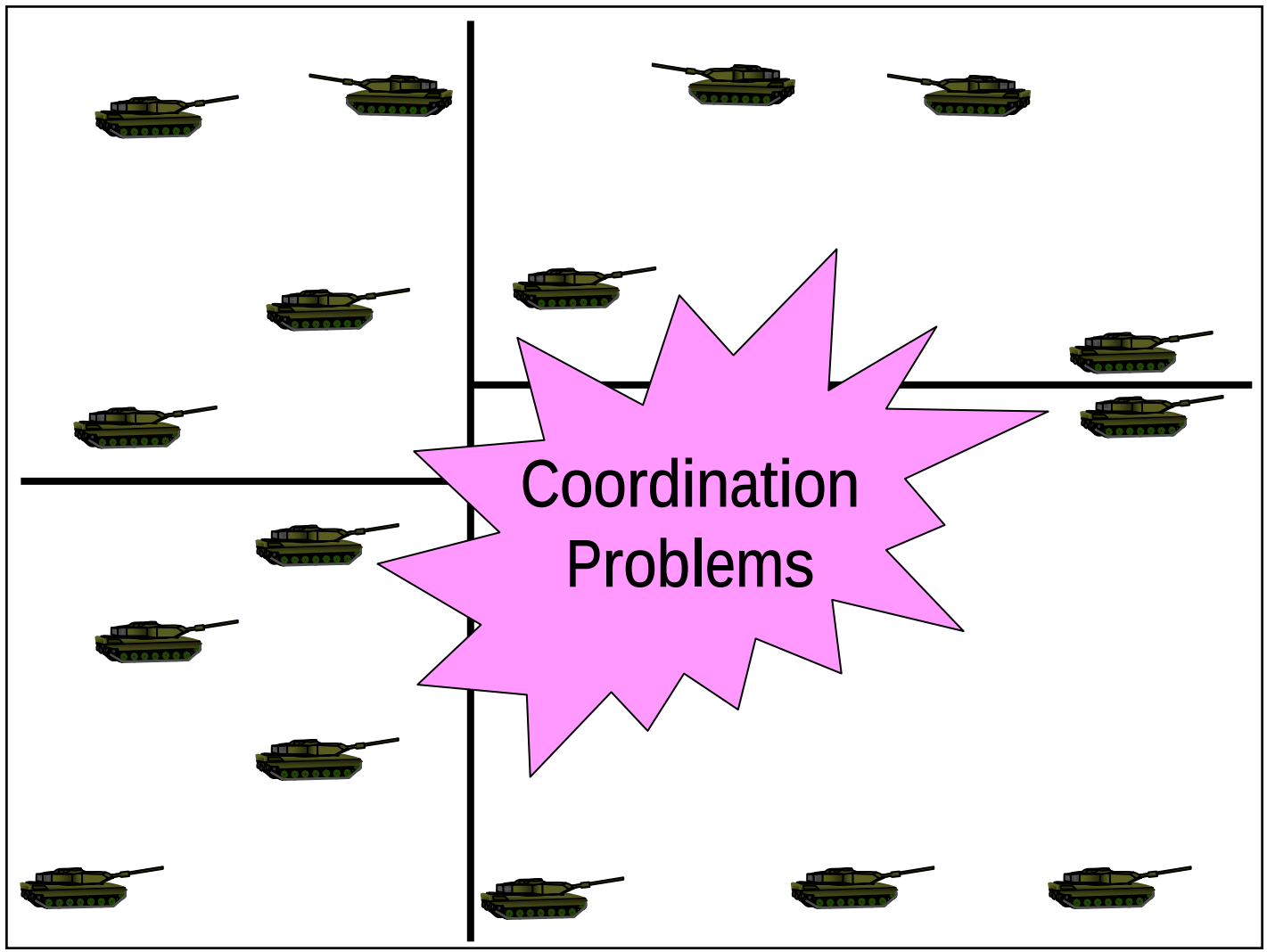

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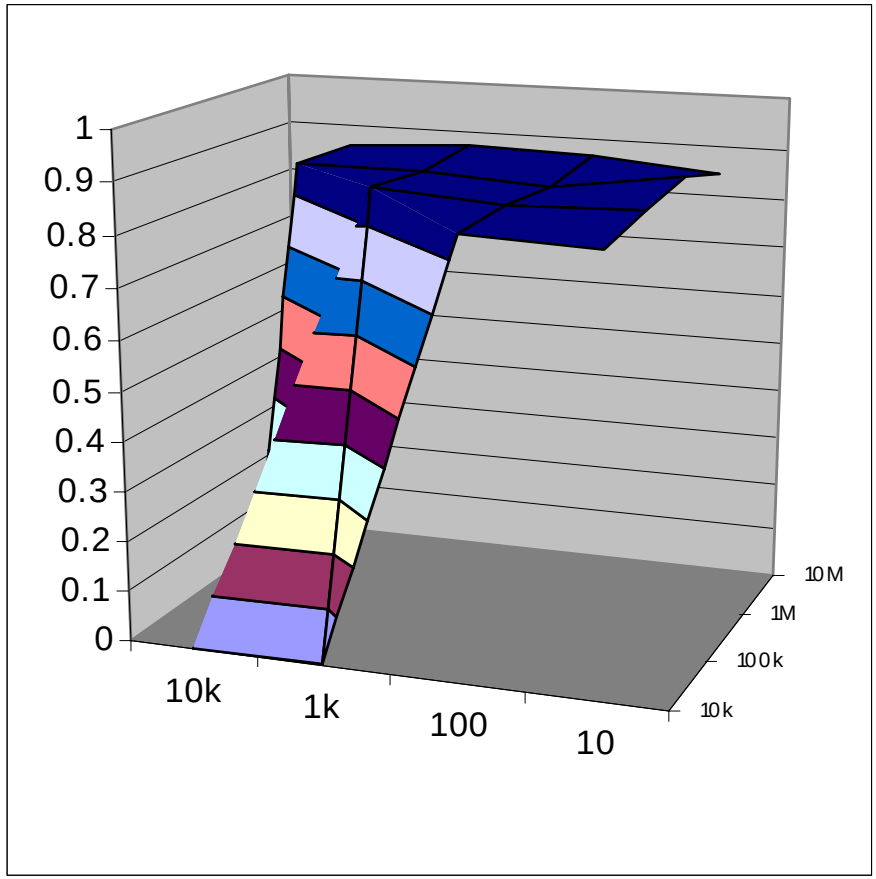
Poor Results — Insufficient Coordination



Solution: More centralisation, or else
self-synchronisation between “leaves” of the tree

Conclusions — Centralisation

- For **simple** problems or relaxed time limits, centralised approach is often best.
- Centralisation provides a “knowledge edge” — can find best possible approach.
- Information Technology in HQ assists this.
- **Example**: Air Tasking Order for fixed or slow-moving targets.

Conclusions — Self-Synchronisation

- For **difficult** problems under time pressure and with a **fast network**, self-synchronised approach is often best.
- Can only hope for a “good enough” answer for these problems, and would like to get it **first** (“tempo edge”).
- Are present-day networks and processes fast enough for this?

Conclusions — Hierarchies

- Hierarchies are a traditional compromise.
- "Divide and Conquer" simplifies hard problems, but doesn't give best answer.
- Coordination problems may occur at boundaries.
- Solution: More centralisation (assisted by IT in HQ), or else self-synchronisation between "leaves" of the tree (assisted by fast networks and by IT in "leaves")

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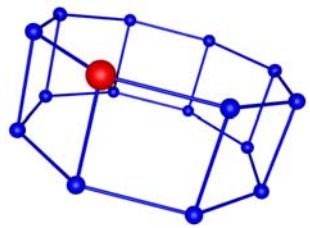
Any Questions?

1. Centralised vs Self-Synchronised networks



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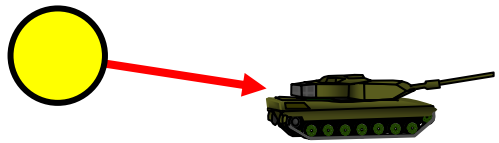

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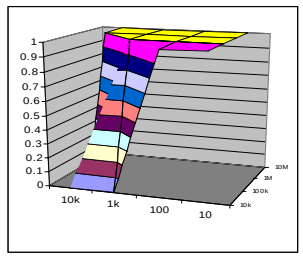

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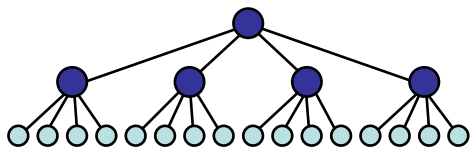

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