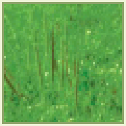
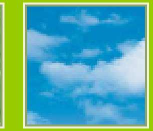

Network Security:
Making the Network Intelligent

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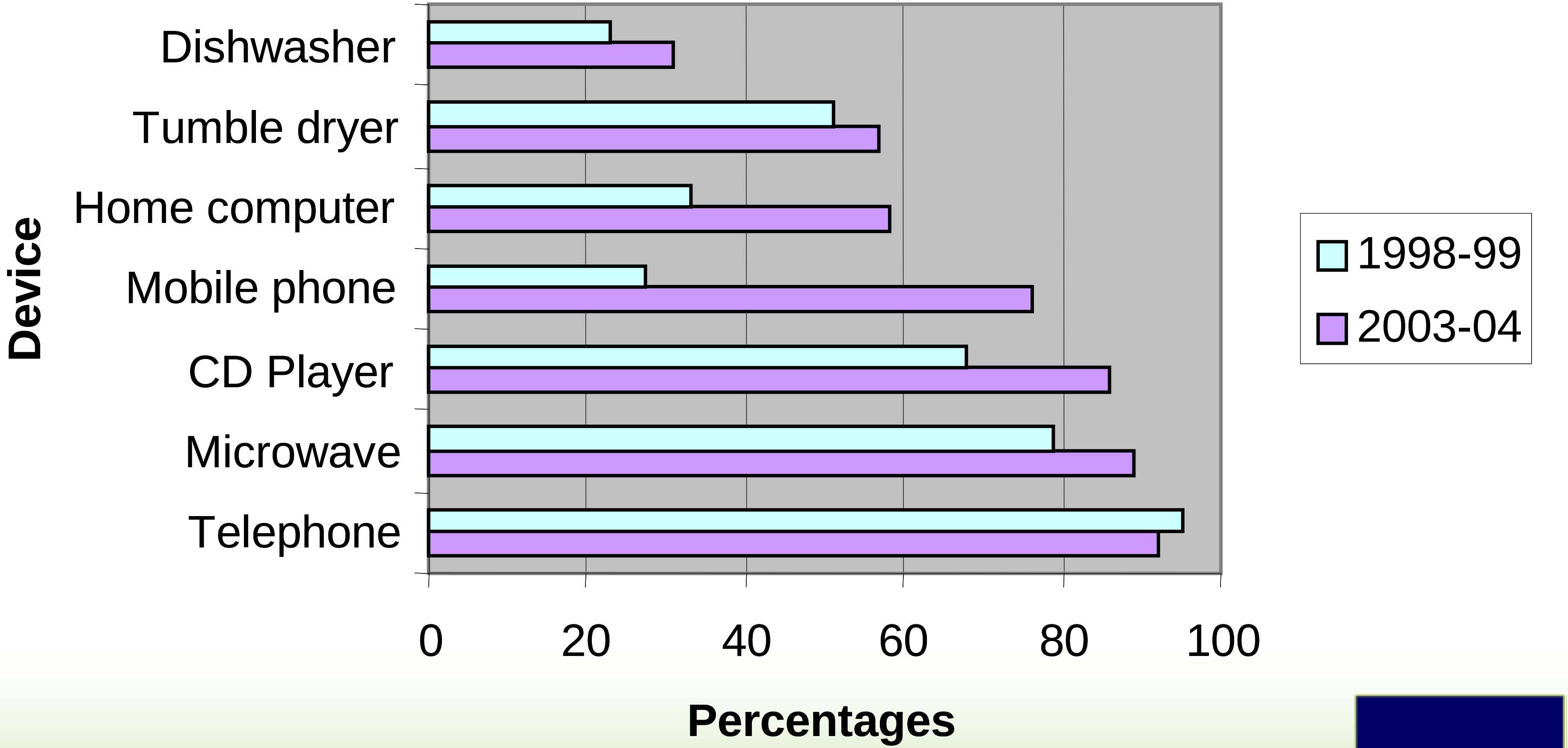
Overview

- Trends in computing
  - New applications
  - New environments
  - Security issues persist
- Current security approaches
  - Models for security are not coping
  - Too little flexibility
  - Too much effort required
- Making the network intelligent
  - Responsibility on nodes to become more involved
  - Responsibility on network to become more cooperative
- Example proposal
  - Distributing knowledge for DRM

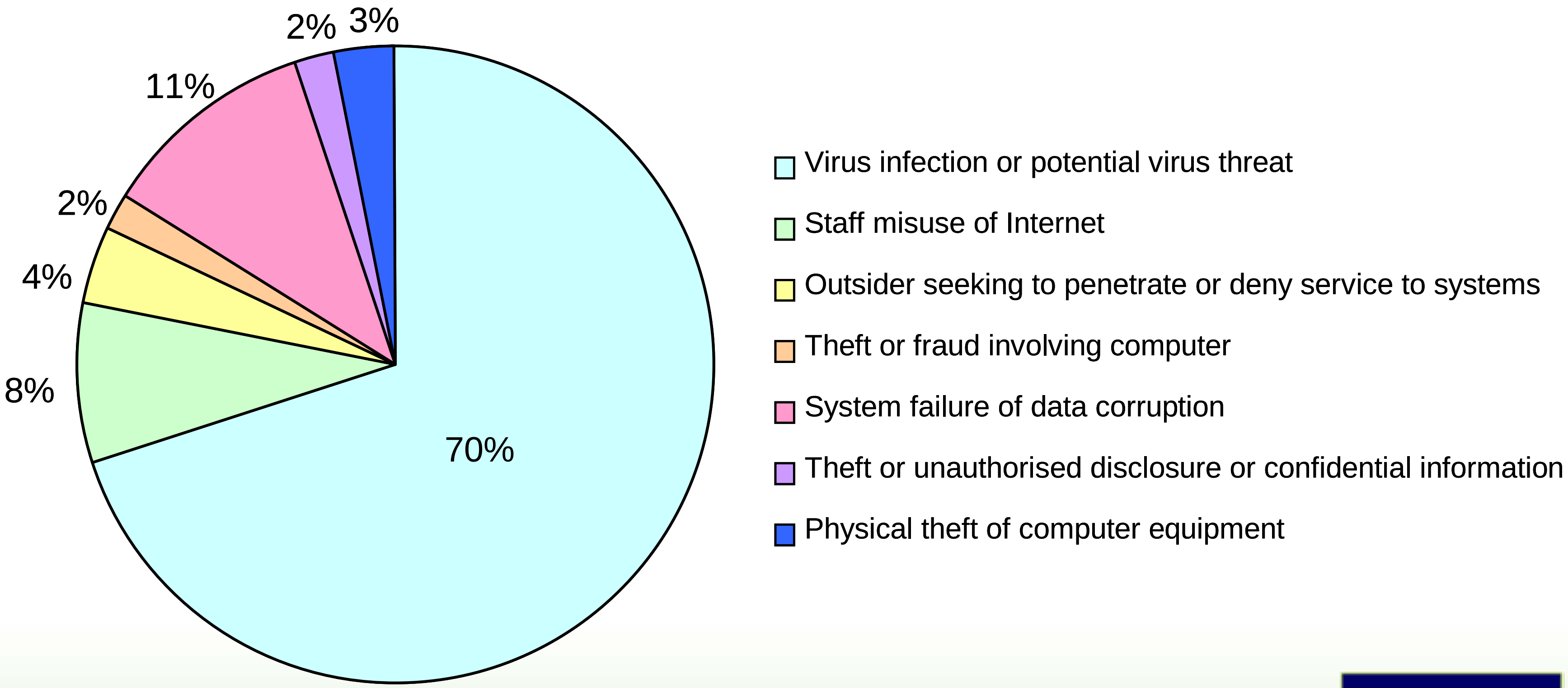
Usage of consumer durables



Changing nature of computing

- Increase in number of units
  - From one per several persons
  - To several per person
- Diversification in type of device
  - From desktop PCs and workstation terminals
  - To smart phones, PDAs, and MP3 players
  - Further ahead; all consumer devices may allow networked control
  - Even further ahead; sensor networks to enable pervasive computing
- Change in security?
  - Insider threat still the most serious
  - Viruses the most prolific
  - Patch management is increasingly time consuming
  - Requires skilled administrators to handle
  - Is any progress being made?

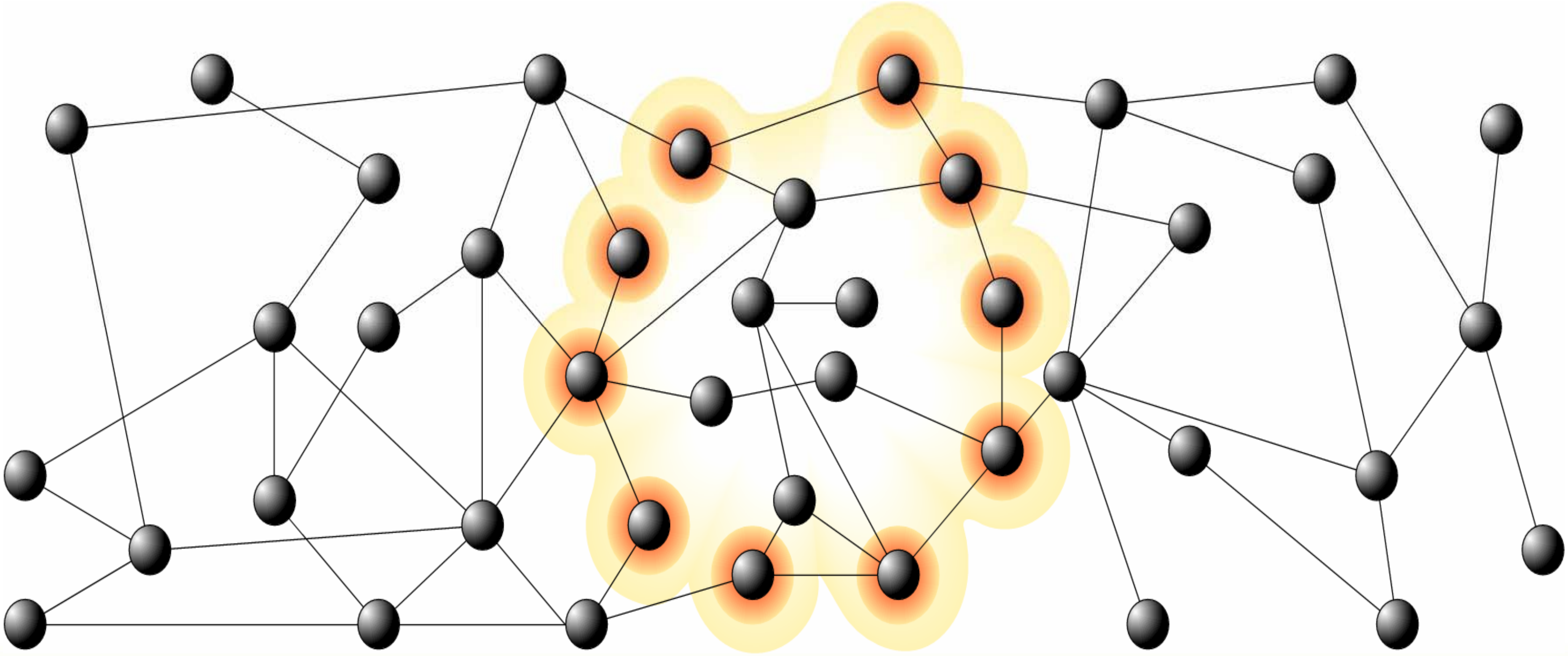
Security incidents in business



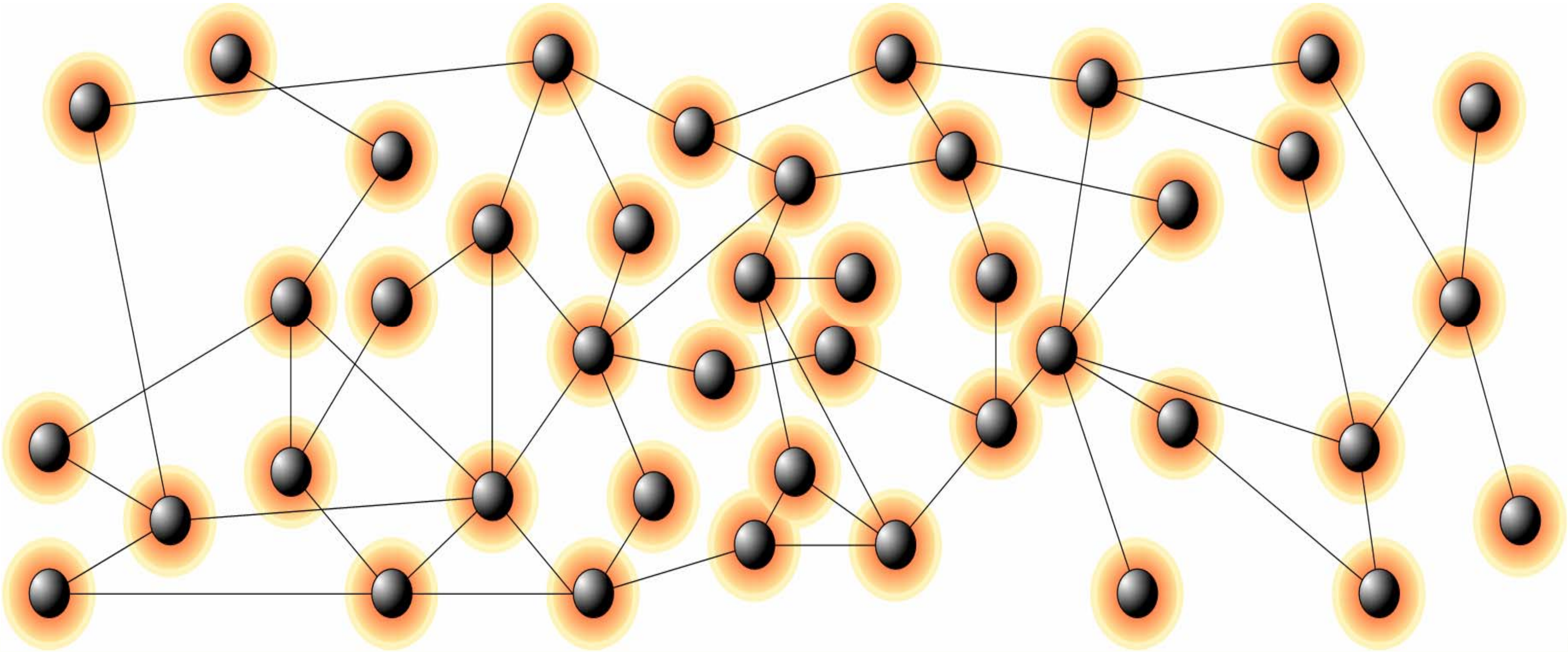
How is security tackled

- Perimeter model
  - Inside the perimeter is trusted
  - Concentrates effort into monitoring at the perimeter
  - Firewalls and Intrusion Detection Systems
  - Has not solved the network security problem
- Atomic model
  - Each node is responsible for its security, e.g. home computer
  - Blunt; all machines expend considerable effort
  - Assumption that security can be handled per node
- Bulkhead model
  - Somewhere in between the perimeter and bulkhead model
  - Security is handled on some nodes only which protect others
  - Careful distribution required to create the best balance

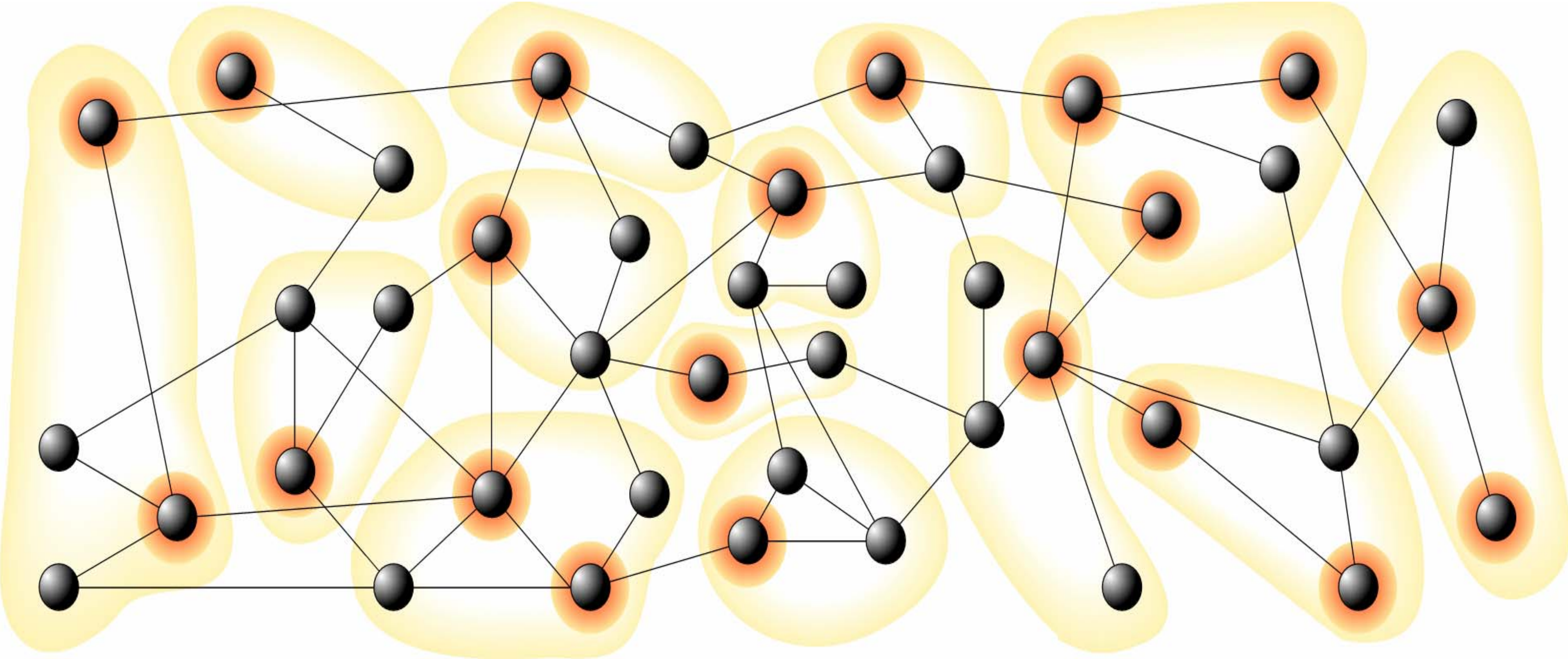
Perimeter Model



Atomic Model



Bulkhead Model

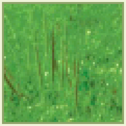
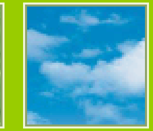


Intelligent network

- The existing models don't make the best use of the network
- This is problematic for pervasive computing
  - Many, or most, nodes cannot work in atomic model
  - Perimeter model not appropriate
  - Perimeter and bulkhead assume some level of organisation
- Challenge: can we distribute the functionality of security across the network?
- Example using cellular automata
  - Cells in a grid, each is connected in a network to direct neighbours
- Game of life
  - If less than two live neighbours, cell is lonely and dies
  - If four or more live neighbours then cell is crowded and dies
  - If cell has three alive neighbours then comes to life
  - Successive steps generate an emergent behaviour

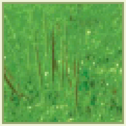
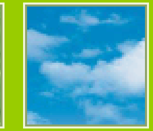
Application to networking

- Assign neighbours to each node in a network
  - Can easily be done as part of a distributed joining protocol in ad hoc or peer to peer network
- All nodes share state with neighbours
- Define rules to allow reaction to neighbours state and change own state
- Advantages
  - Each node is only performing part of the overall process
  - Simple processing can lead to complex systems
  - Sharing and cooperation can uncover network wide problems
- What sort of mechanisms could this be applied to?
  - Virus checking
  - Digital Rights Management (DRM)

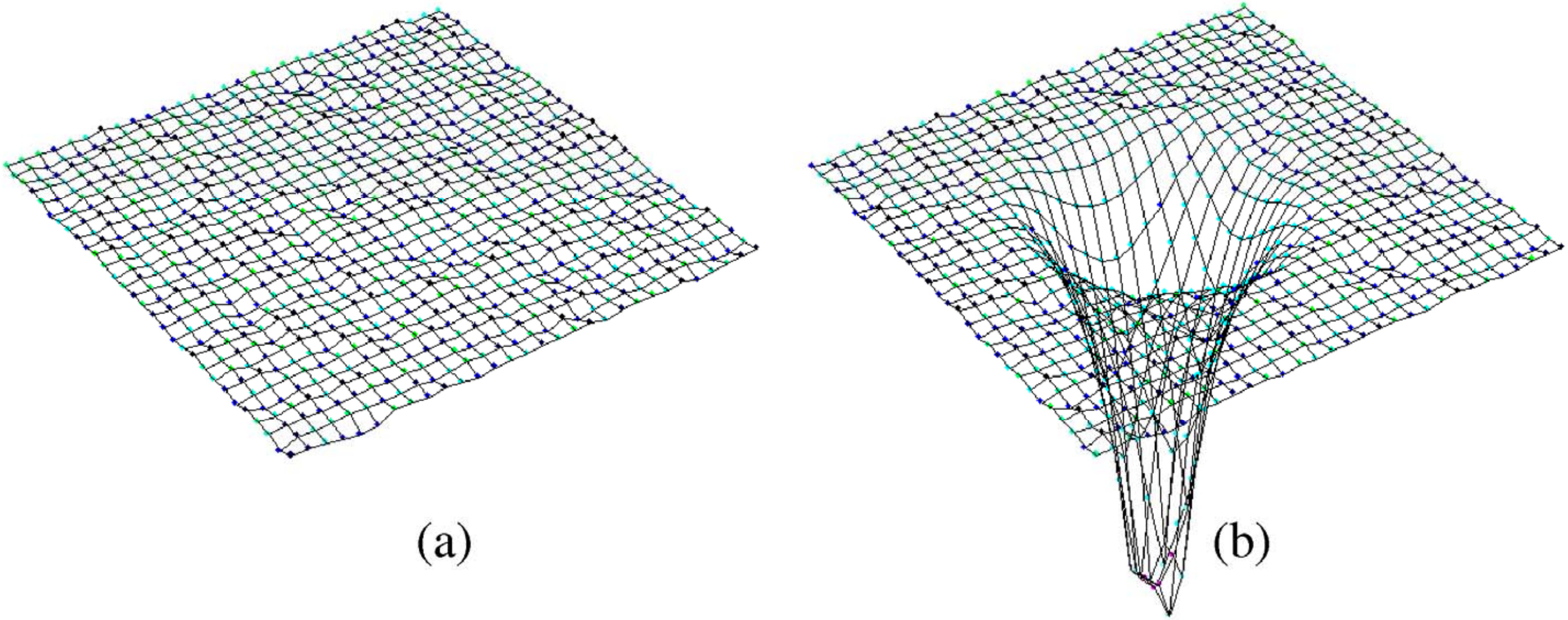



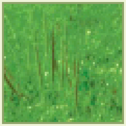
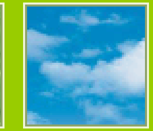
Community Security Mechanism

- Each node has a security state
- Level goes up or down depending on neighbours state
- Rate of change used to assign trust level to neighbours
- Laplace differential equation used to calculate overall position
- Security level is modelled as height
- Trust as a downward force on the node
- Network links take on ‘elastic’ property
  - If links are stretched they pull back

Effect of sharing

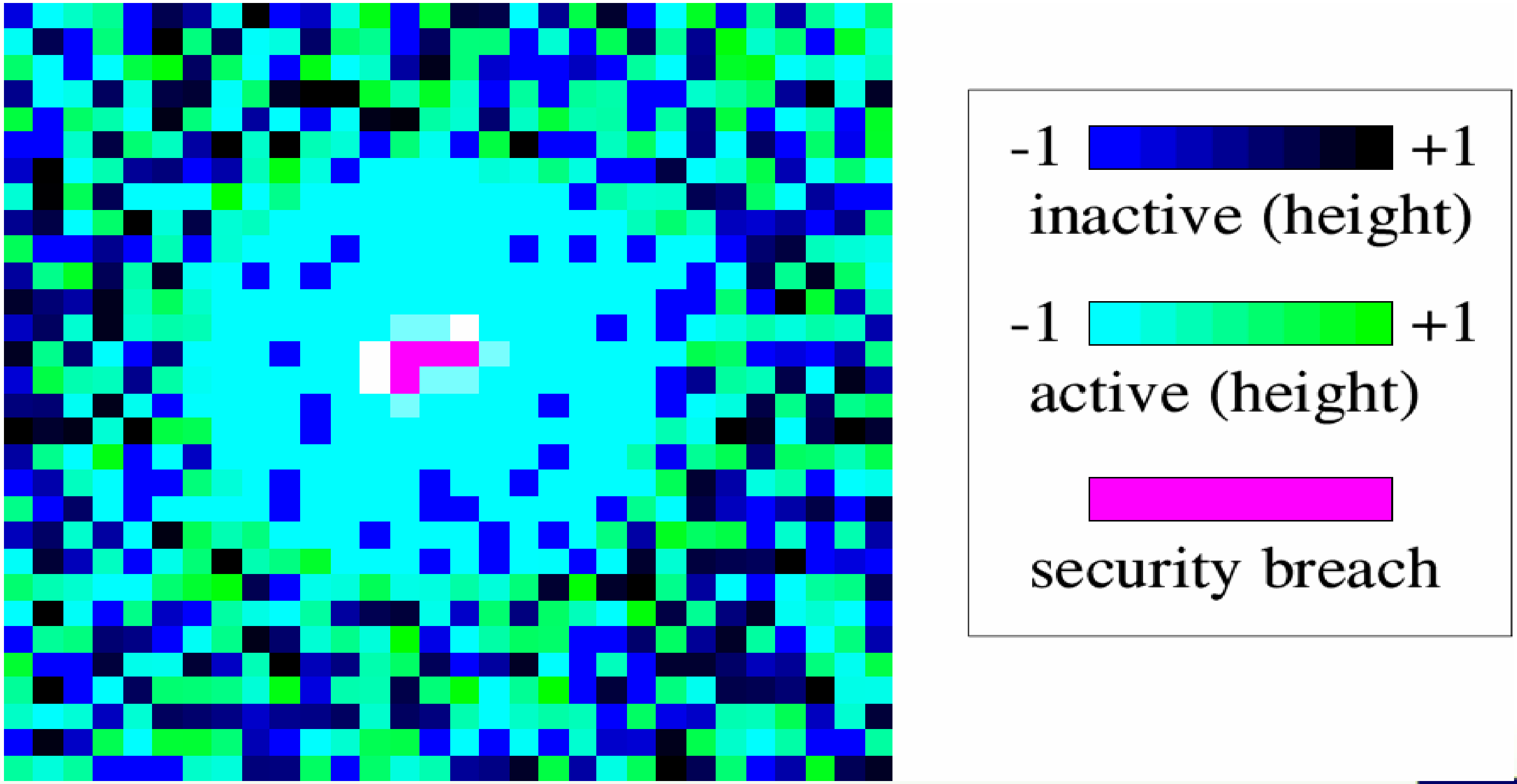


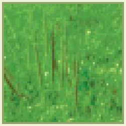
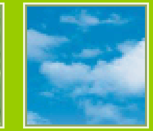



Applying mechanism to DRM

- Community of users operate a cellular automata layer
- Nodes check proportional amounts of network traffic
  - i.e. perform DRM checking on that part of the stream
- Change security and trust levels accordingly
- Neighbours propagate information locally
- Amount of checking scales locally
  - More checking if neighbours are unsafe
  - Less checking is neighbours are safe
- More checking may result in more problems being noticed
  - This is likely if a node is malicious or compromised
- The process isolates unsafe nodes

Isolation of compromised nodes

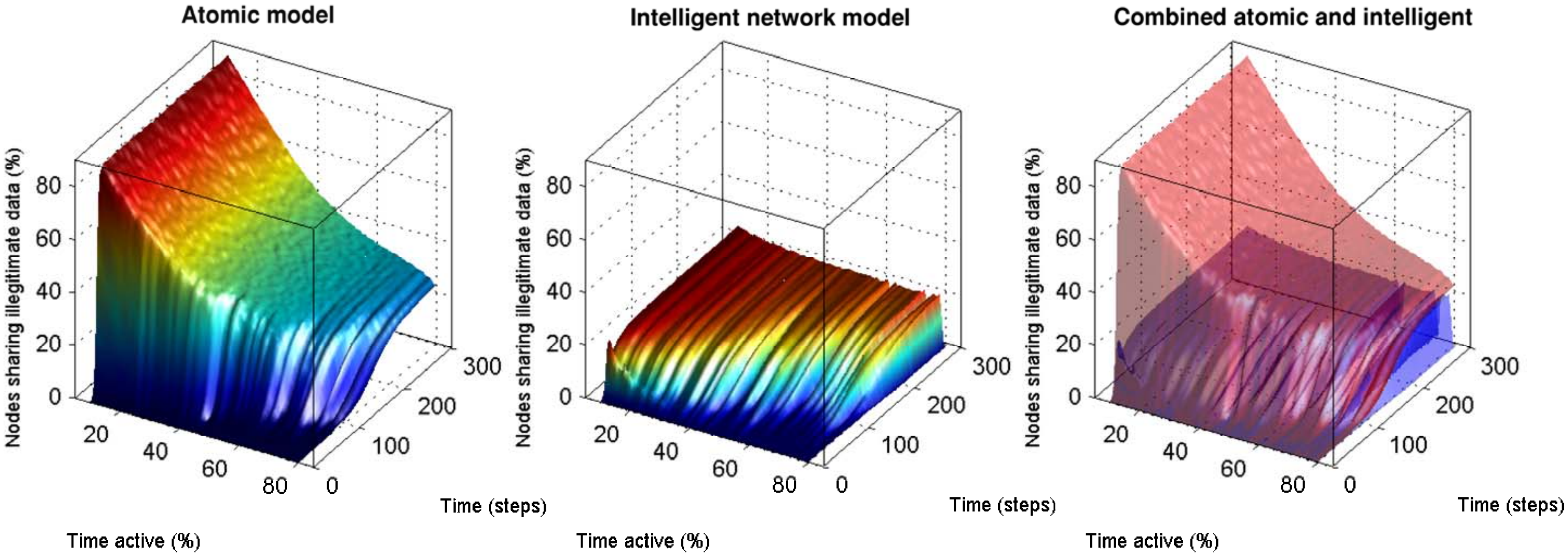


Simulation results

- Tests conducted by varying the parameters for
  - Number of nodes
  - Amount of illegitimate data
  - Amount of checking
- Using 85% checking the system is highly reliable
- Lowering the checking to 20% results become similar to atomic model
  - Saving 80% of checking!
- Self-enforcement could be better than tight controls from content providers
  - Controls are controversial
  - Acceptance of some loss may be inevitable
  - Cost to implement may be lower

Simulation results comparison



Summary

- Computing continues to change dramatically
- Internet has played a major role in the last decade
- Pervasive computing looks likely to follow…
  - Heterogeneous, resource contrained
- Security has got **worse** with increased communications
- Traditional perimeter model has been limited
- Atomic model could prove inefficient
- ‘Intelligent’ middle ground?
  - Example using cellular automata
  - DRM example isolates misbehaving nodes
  - Nodes assess neighbours and react to trust levels
  - Results suggest less processing for similar effect as atomic model
  - Potential for detection of security through ‘emergent behaviour’