UNIVERSITY OF CAMBRIDGE

FRESnel

Federated Shared Sensor Networks

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Motivation

Structural Health Monitoring

Environmental Sensing

Industrial sensing

Mobile Urban Sensing

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Industrial sensing

Typical sensor networks are single-app, single-user networks

Shortcomings

- High cost of deployment and maintenance
  - Many organisations are reluctant to do large deployments of sensor networks
  - Short lifetime deployments to avoid the maintenance costs
- Replicated sensing infrastructure
  - Many organisations that need access to similar data or sensing in same locations

Is this the right way forward?

- There is a vision of a sensor reach world
  - Sensing available everywhere
  - Context-aware apps that use sensing infrastructure

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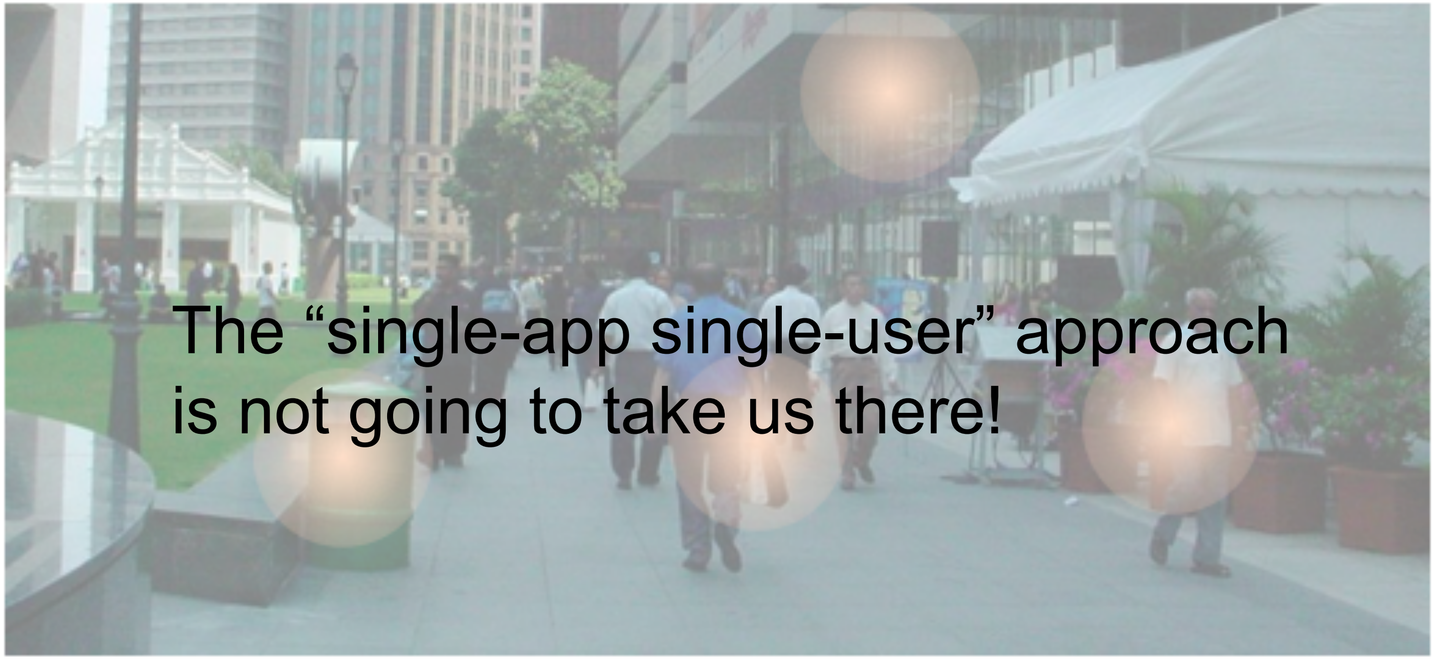


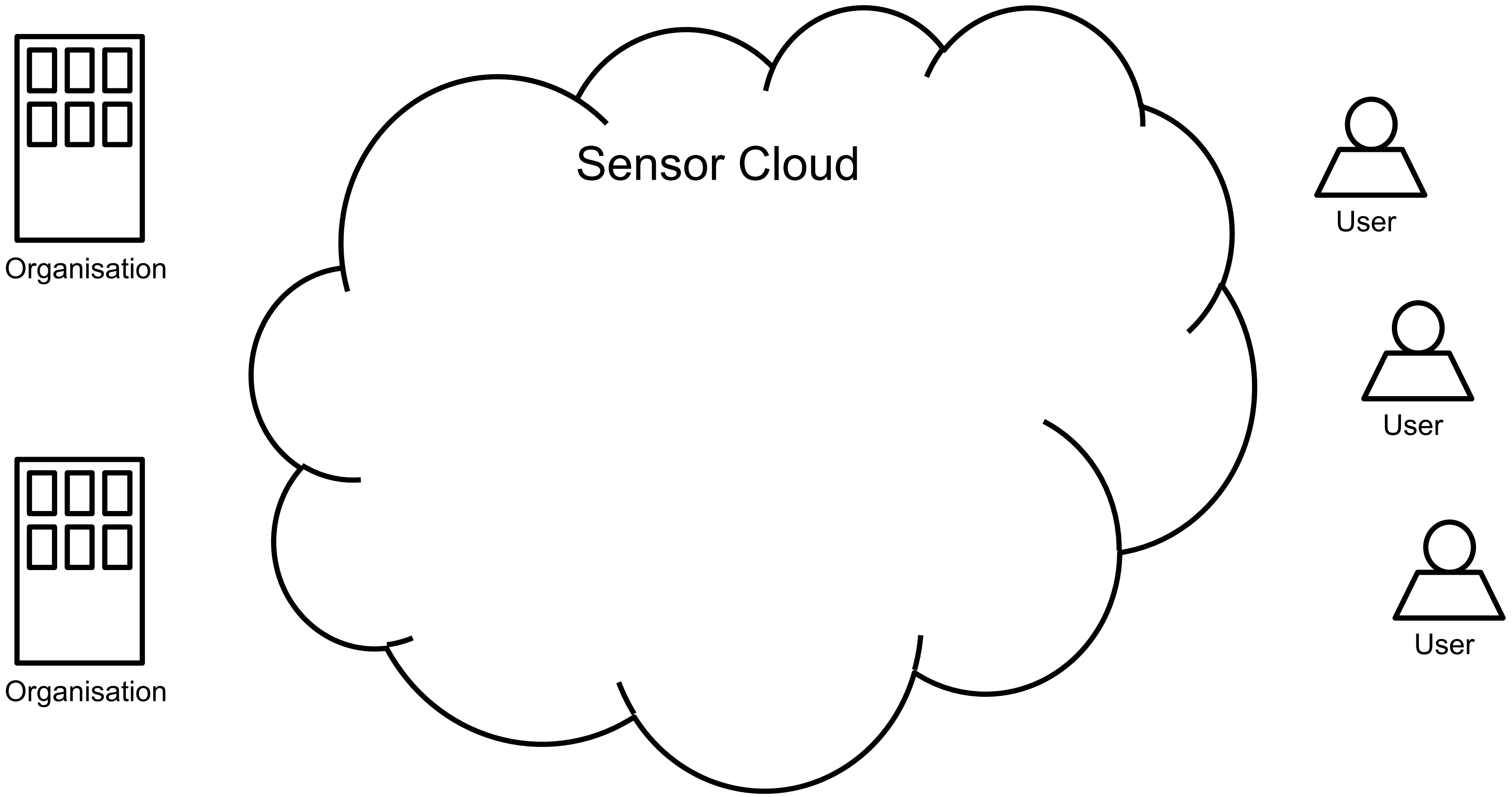
The “single-app single-user” approach is not going to take us there!

The FRESNEL Approach

Shared Federated Sensor Networks

- Sharing
  - Sensor networks can support multiple applications that belong to multiple authorities
- Federation
  - Applications can span across networks that belong to different organisations
- Decoupling of sensing infrastructure and sensing applications

The Vision



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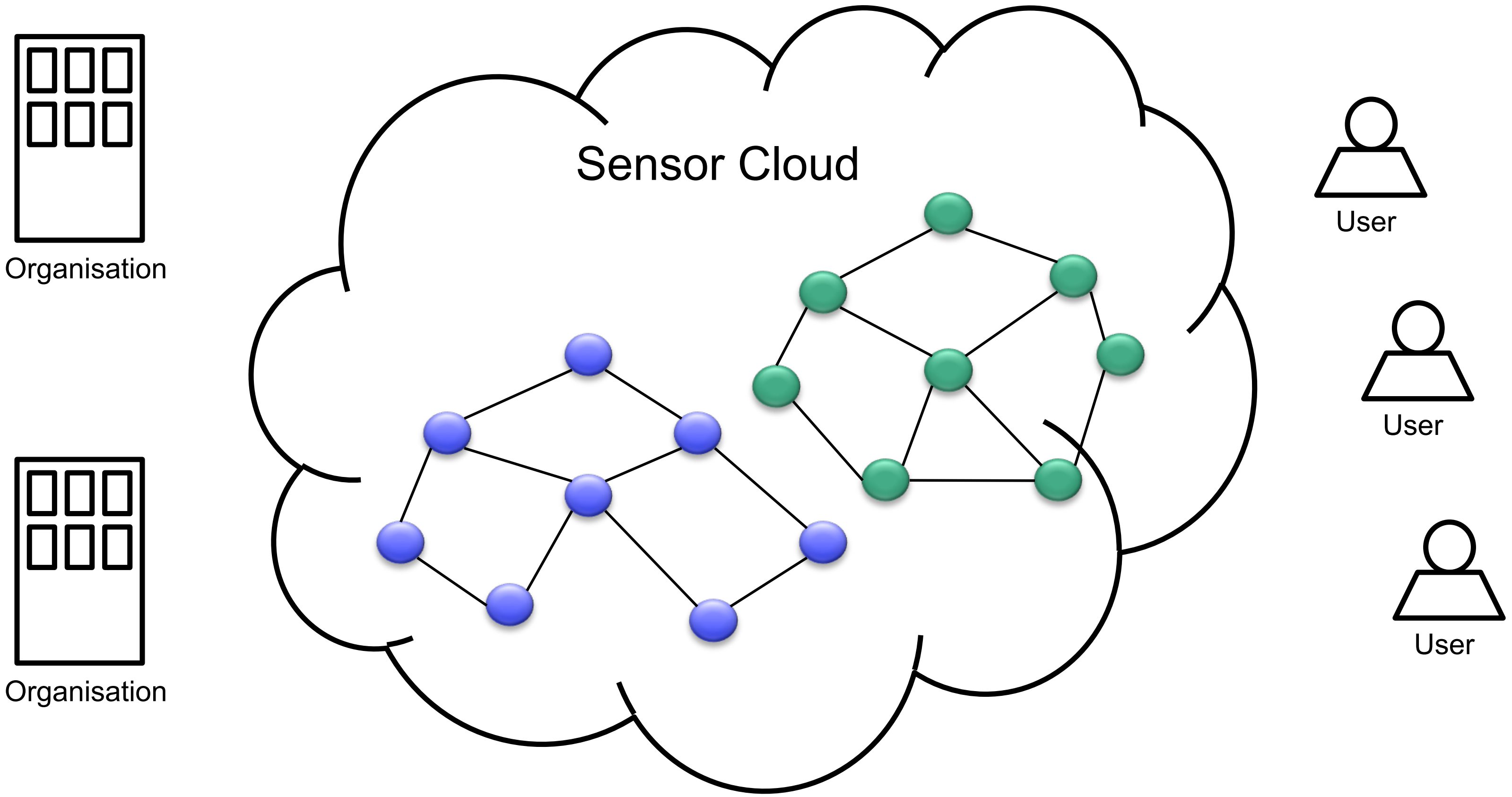

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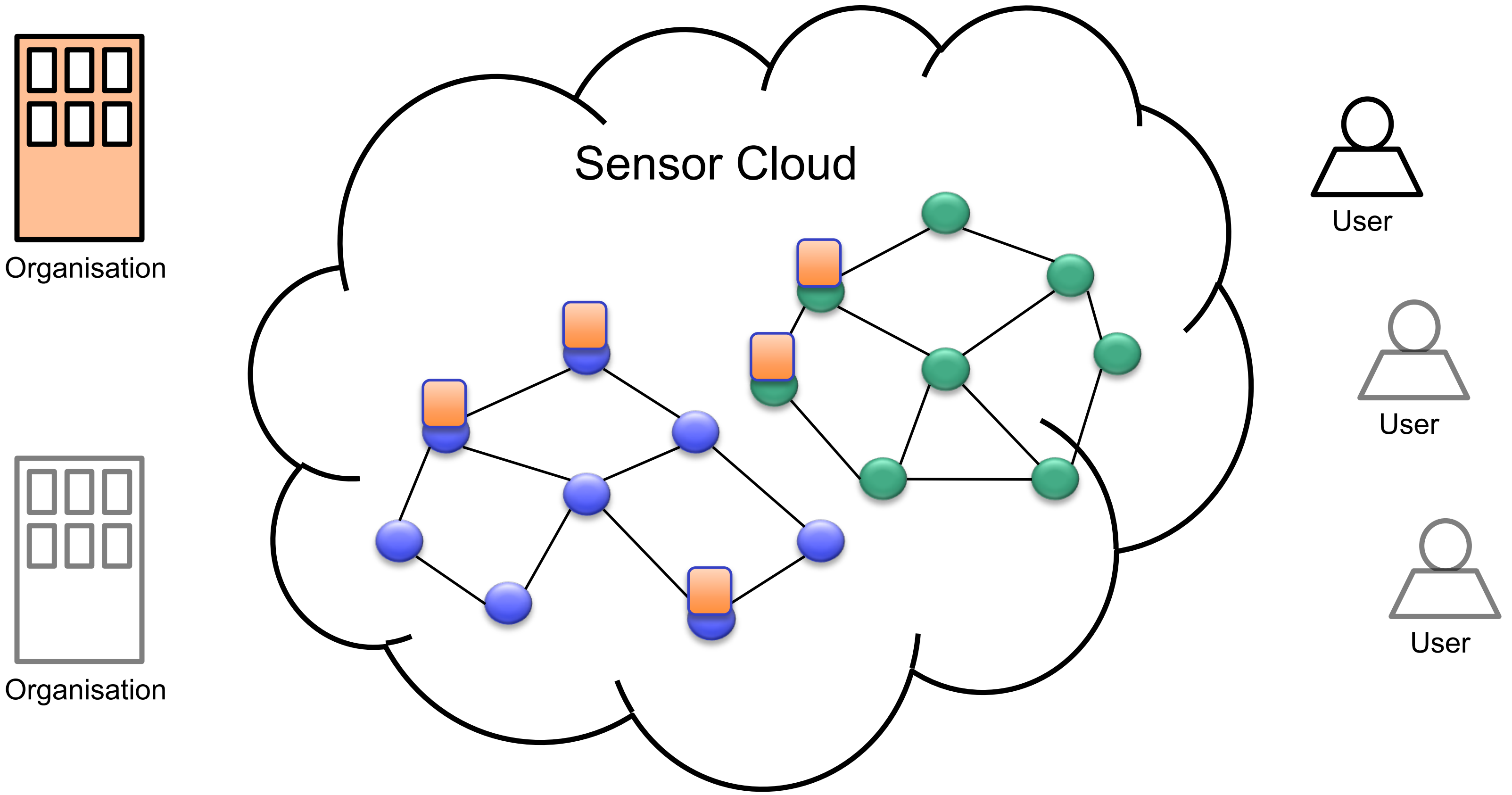

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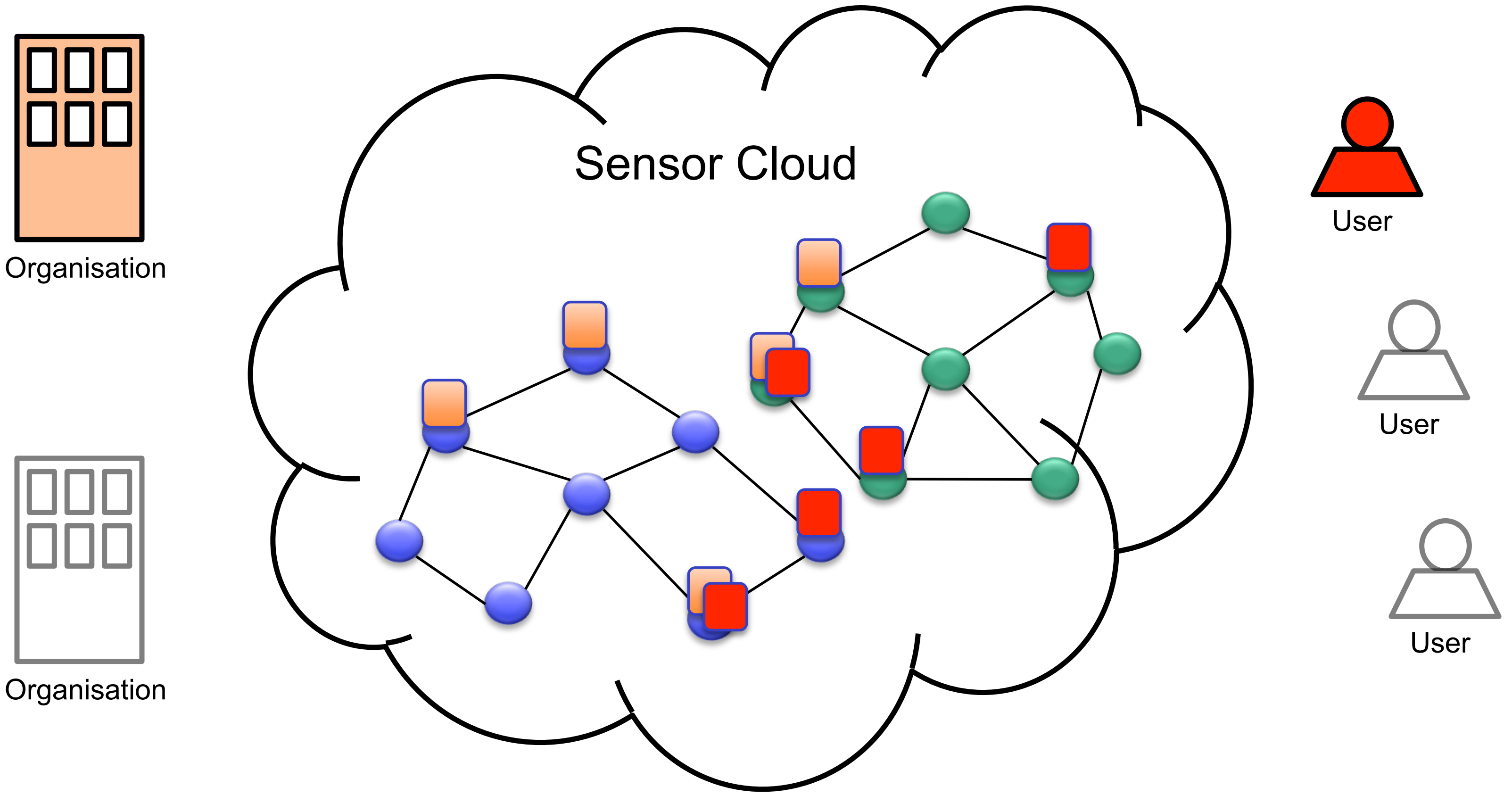

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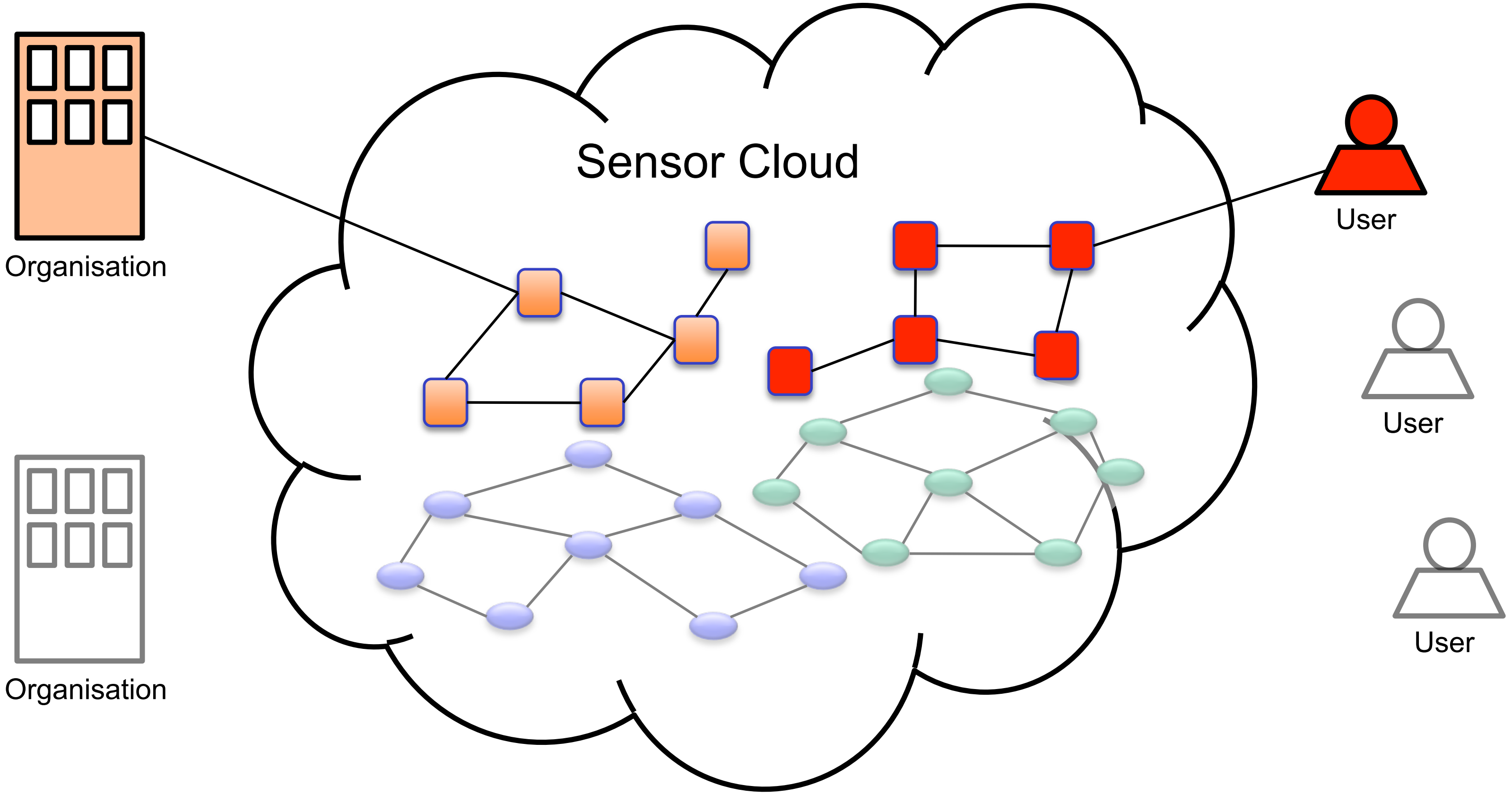


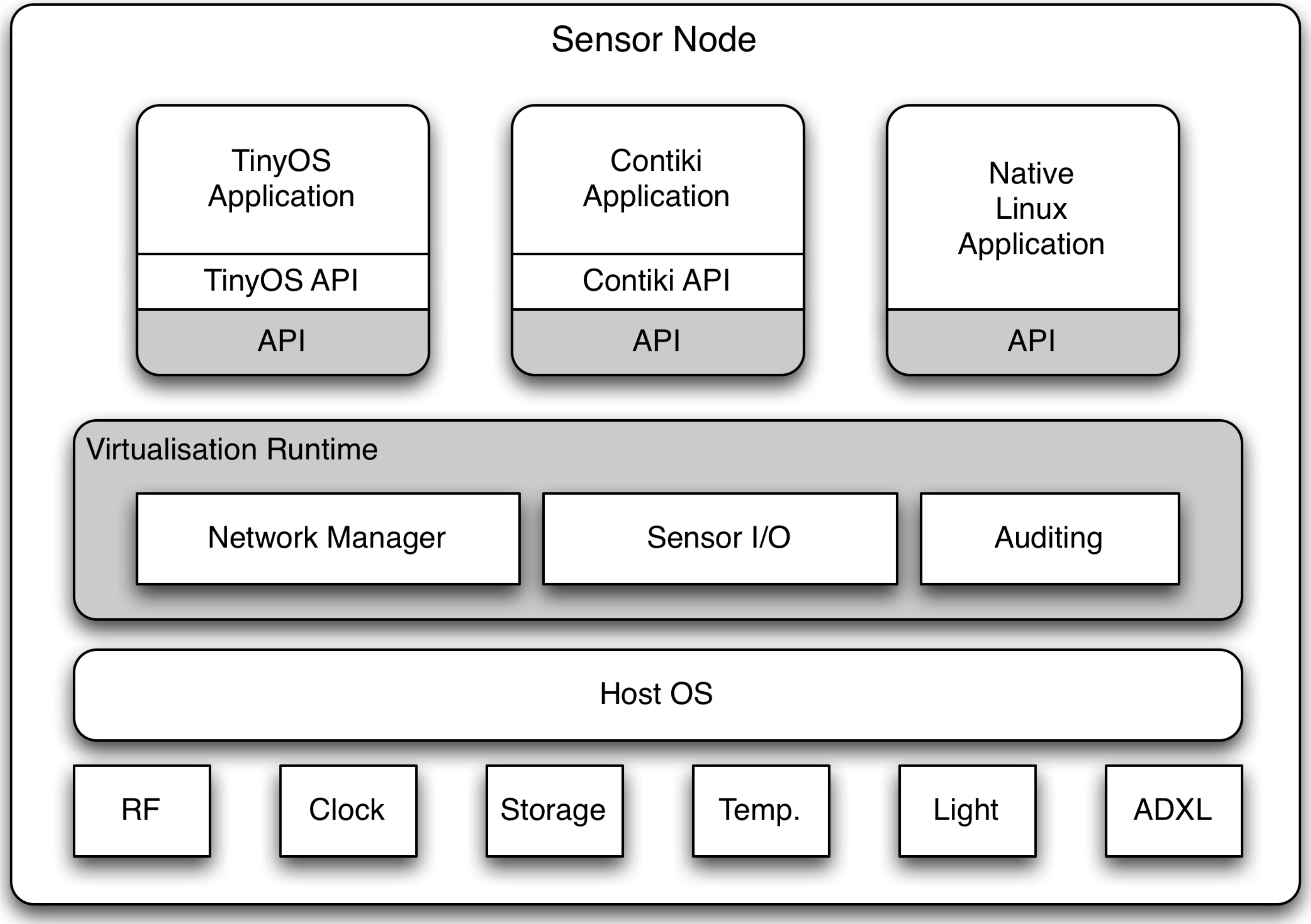
Challenges

- Dynamic Resource Allocation
  - Network owners have their policies on resource usage
  - Application demands will be satisfied according to these policies
- Flexible Network Partitioning
  - Support virtual sensor networks
- Secure and Safe sharing of resources
  - Security and protection from other applications

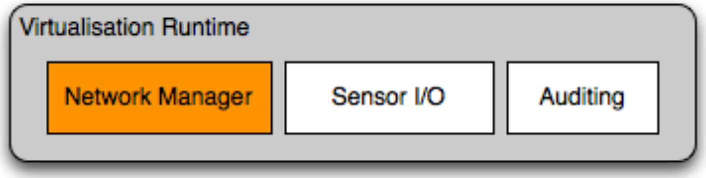
Initial Efforts

- Supporting network sharing
  - Support multiple applications on each node
  - Maintain application isolation
- Support deployment policies specified by multiple stakeholders
  - Network owners
  - Application developers

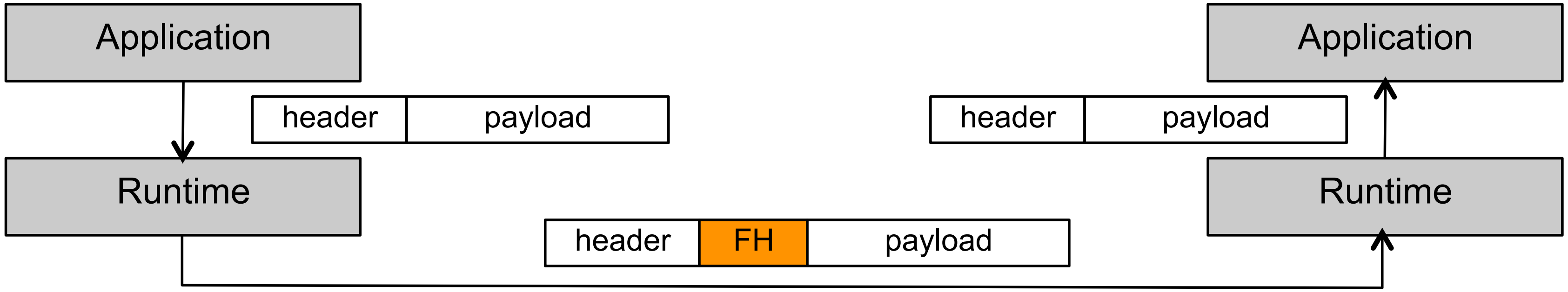
Node Architecture



Network Manager



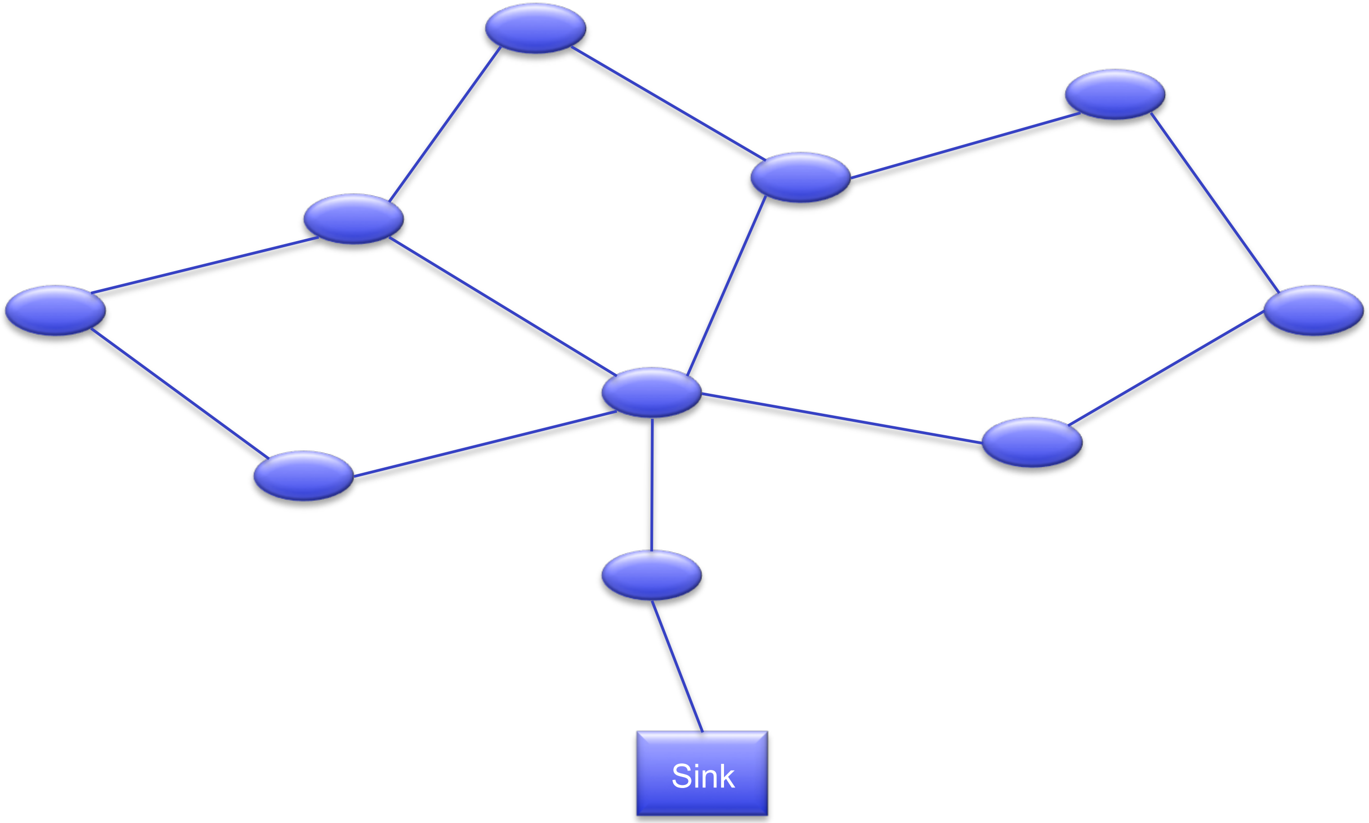
- Shared Network Interface
  - Virtualise and bridge multiple interfaces
    - IEEE802.15.4, USBNet, IP network
  - Isolation of application traffic
    - Runtime tags transmitted data for specific apps and filters on receive
    - Applications have access only to their own traffic



Application Deployment

- Deployment and execution policies from network owner
  - Examples:
    - Accept app if less than N active apps
    - Discard app if traffic over N bps
- Policy matching deployment
  - Deployment is driven by:
    - Attribute patterns specified by the developer
    - Policies on the nodes
- The deployment mechanism generates a sparsely connected overlay network of nodes

Overlay Network



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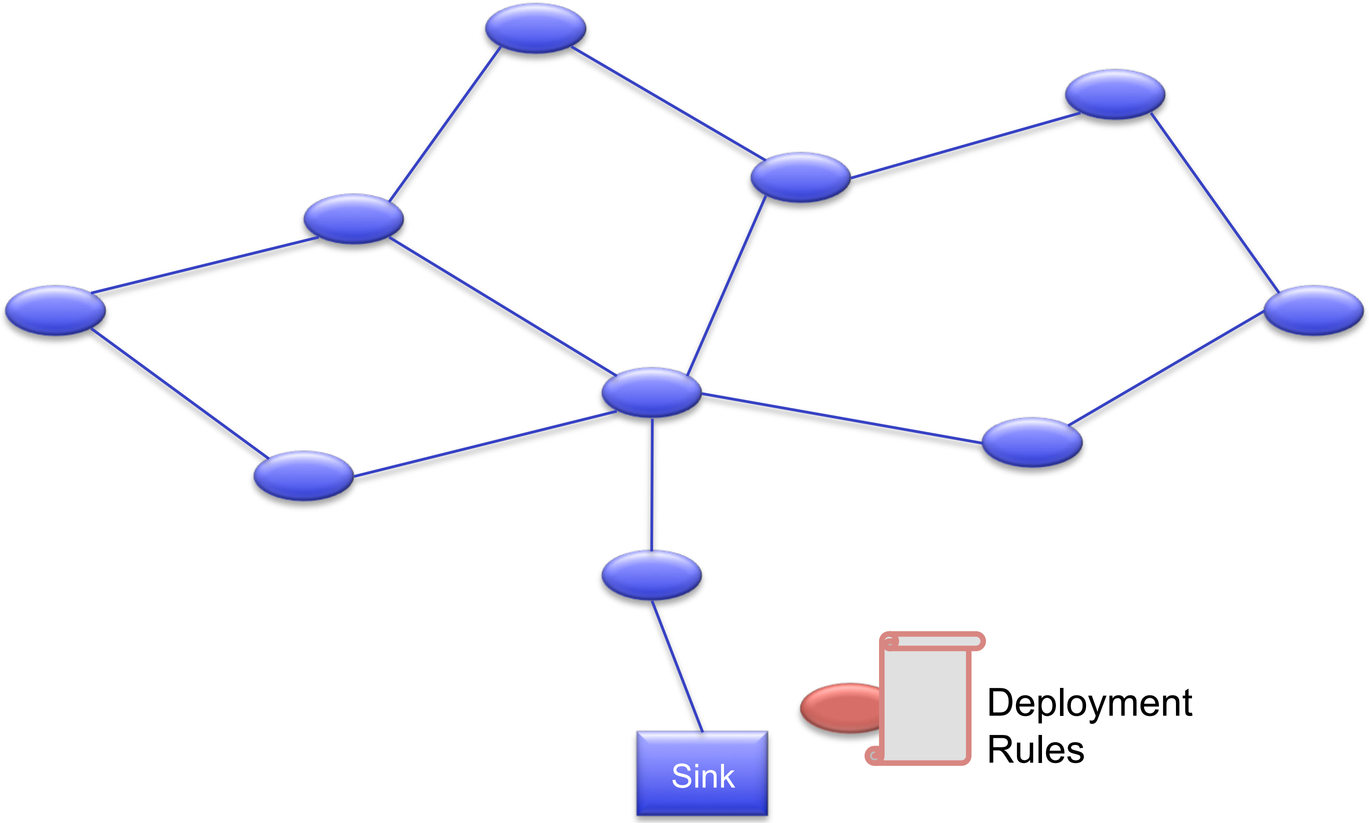

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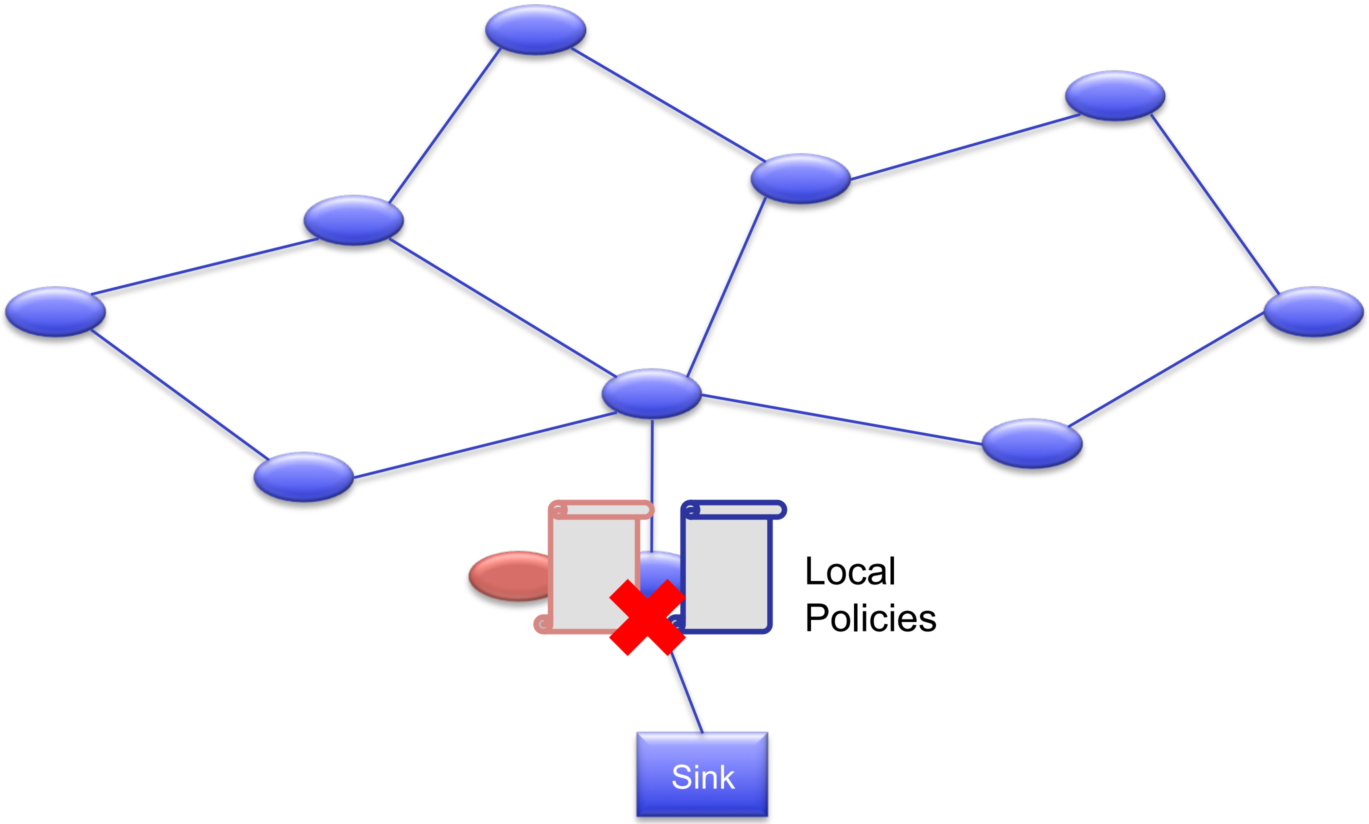

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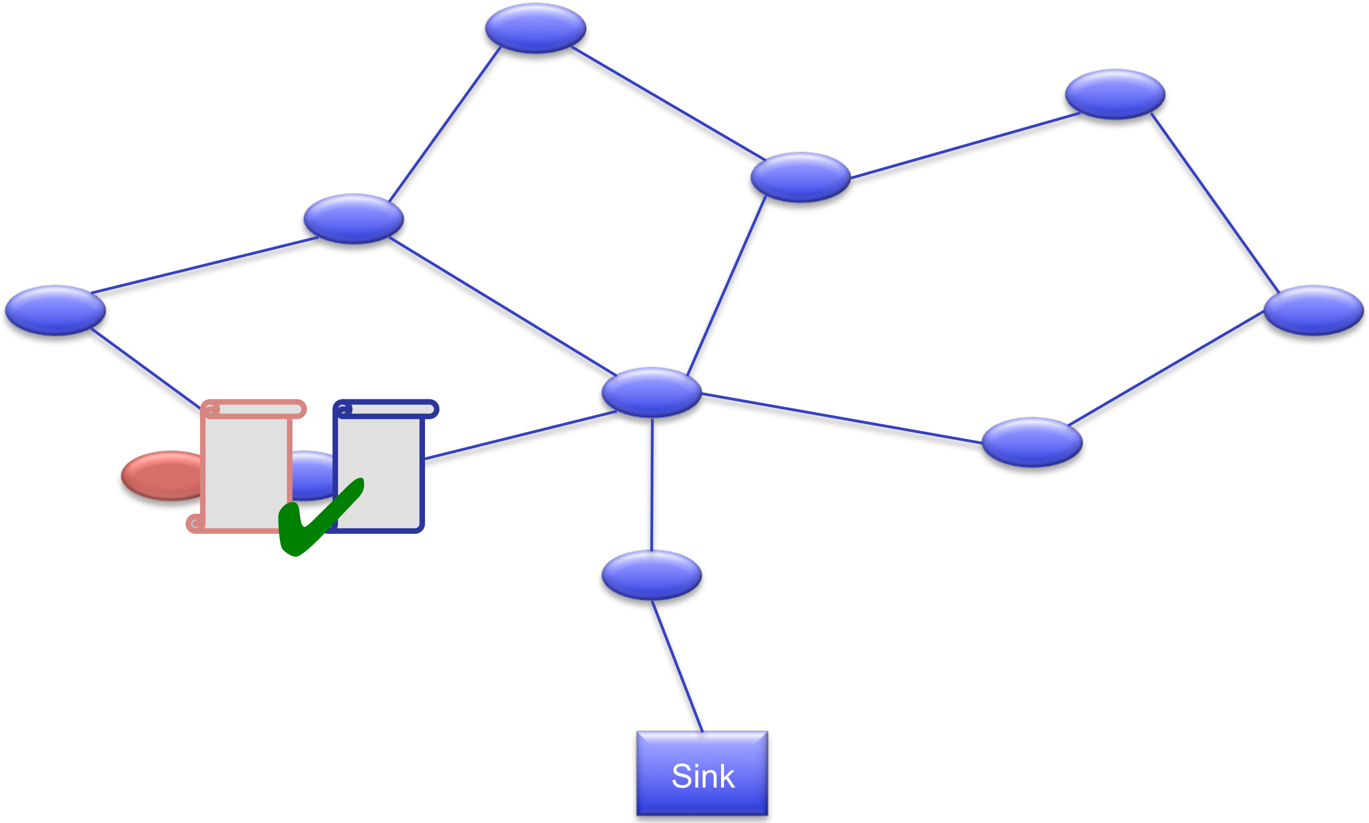

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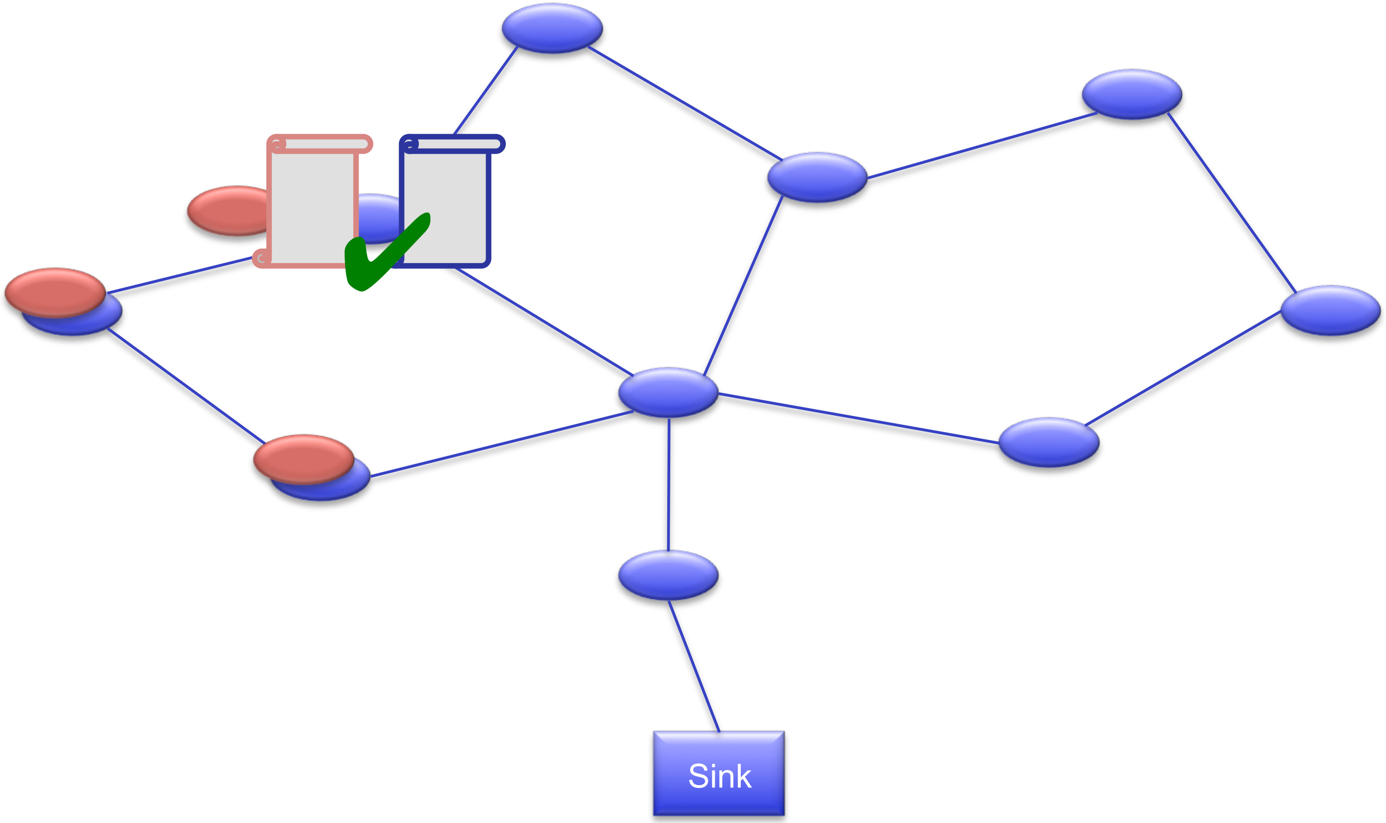

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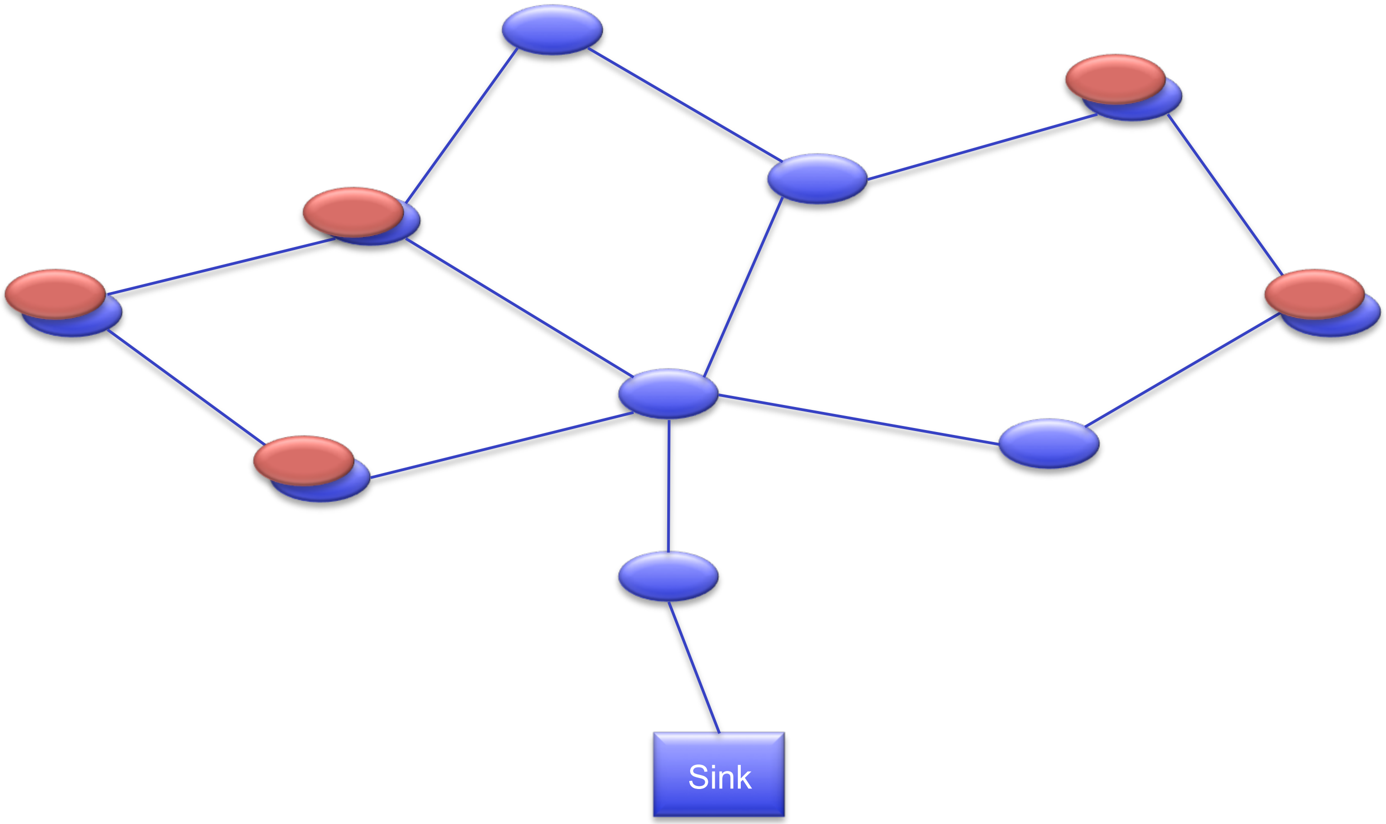

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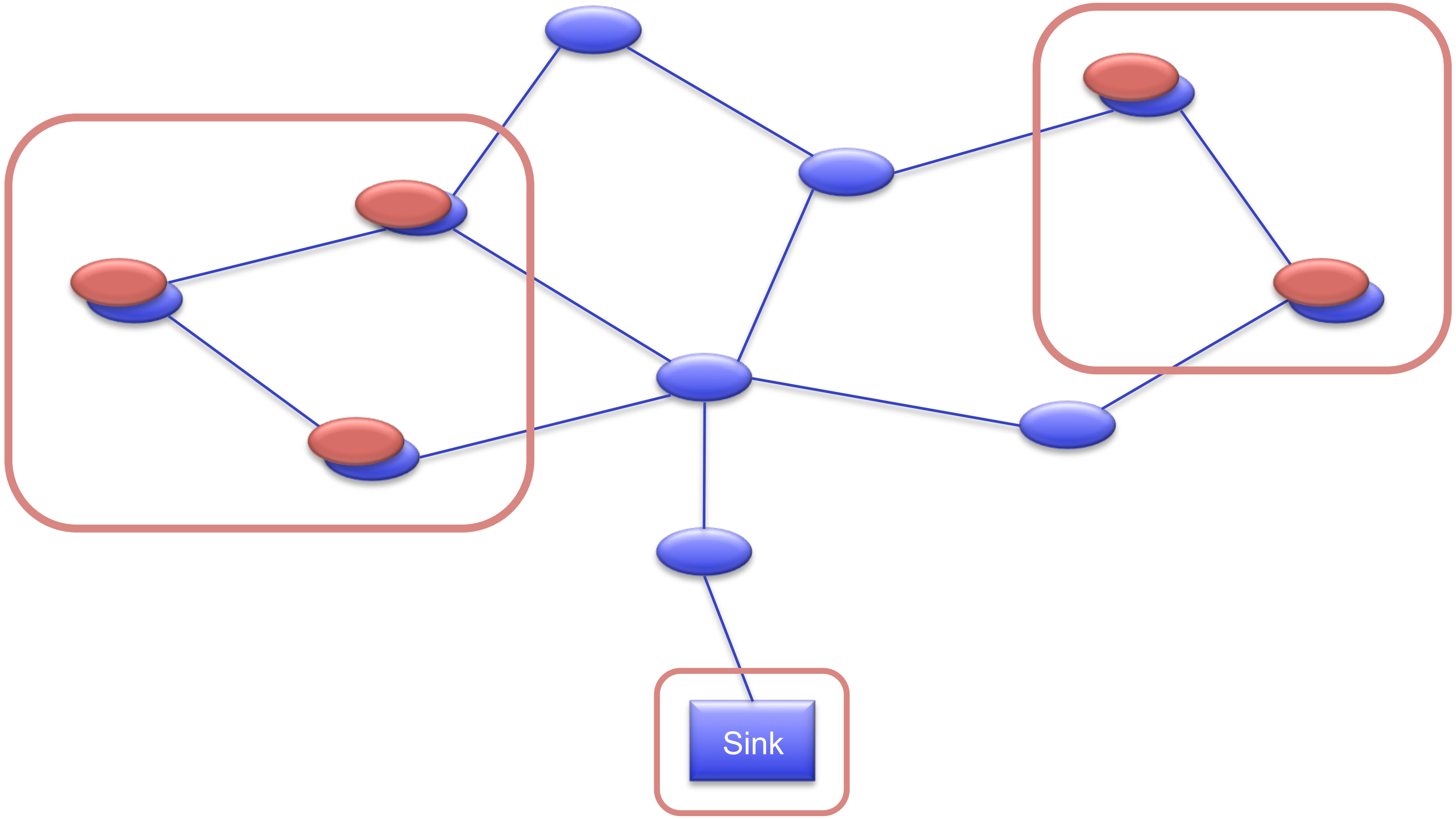

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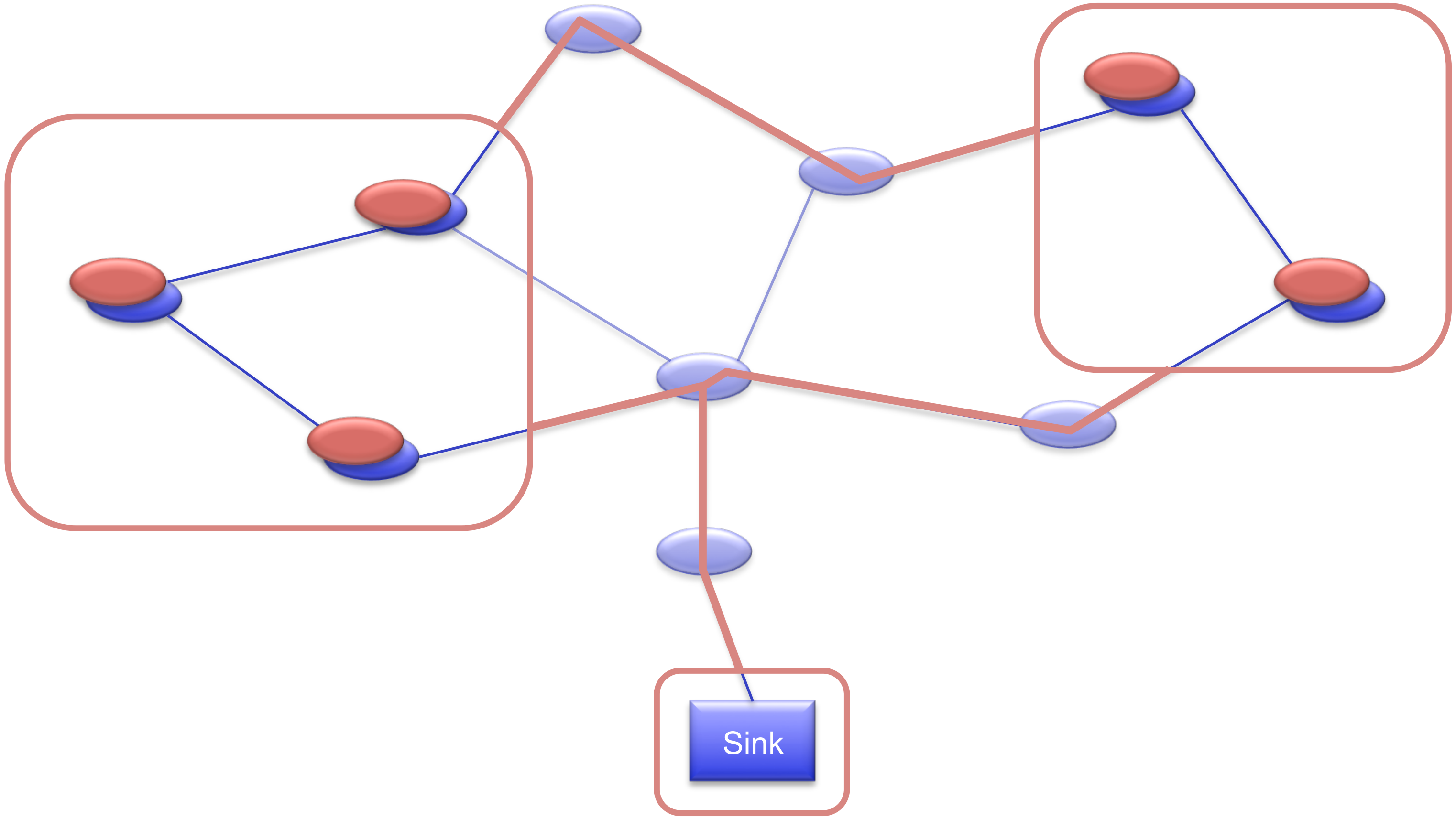

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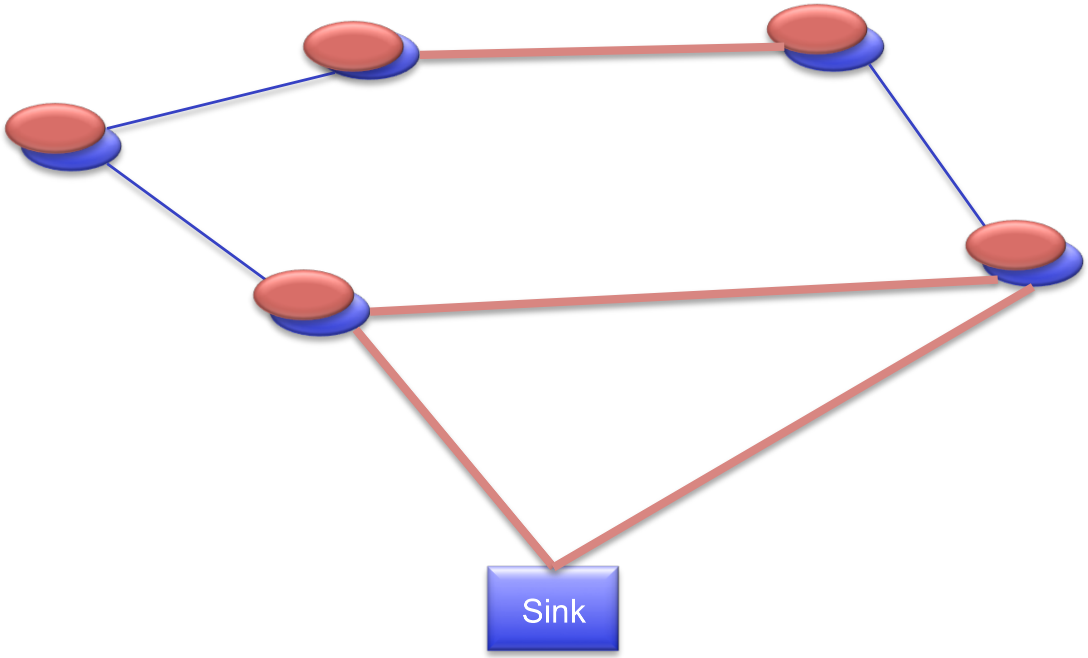

Implementation

- Runtime implemented in C++
  - Native Linux process
  - Runs on multiple devices:
    - imote2, Android phones, PCs
  - Bridges 802.15.4 traffic and WiFi traffic
- Fresnel lib
  - HW access API for native applications
  - TinyOS components that abstract HW access

Deployment

- Planning to deploy a shared sensor network in the Computer Lab building, in Cambridge in the next months.
- The network will offer open access for researchers to deploy their applications in the form of a testbed.
- Next step:
  - Federate our network with other sensor networks