Load Sharing and Bandwidth Control in Mobile P2P Wireless Sensor Networks

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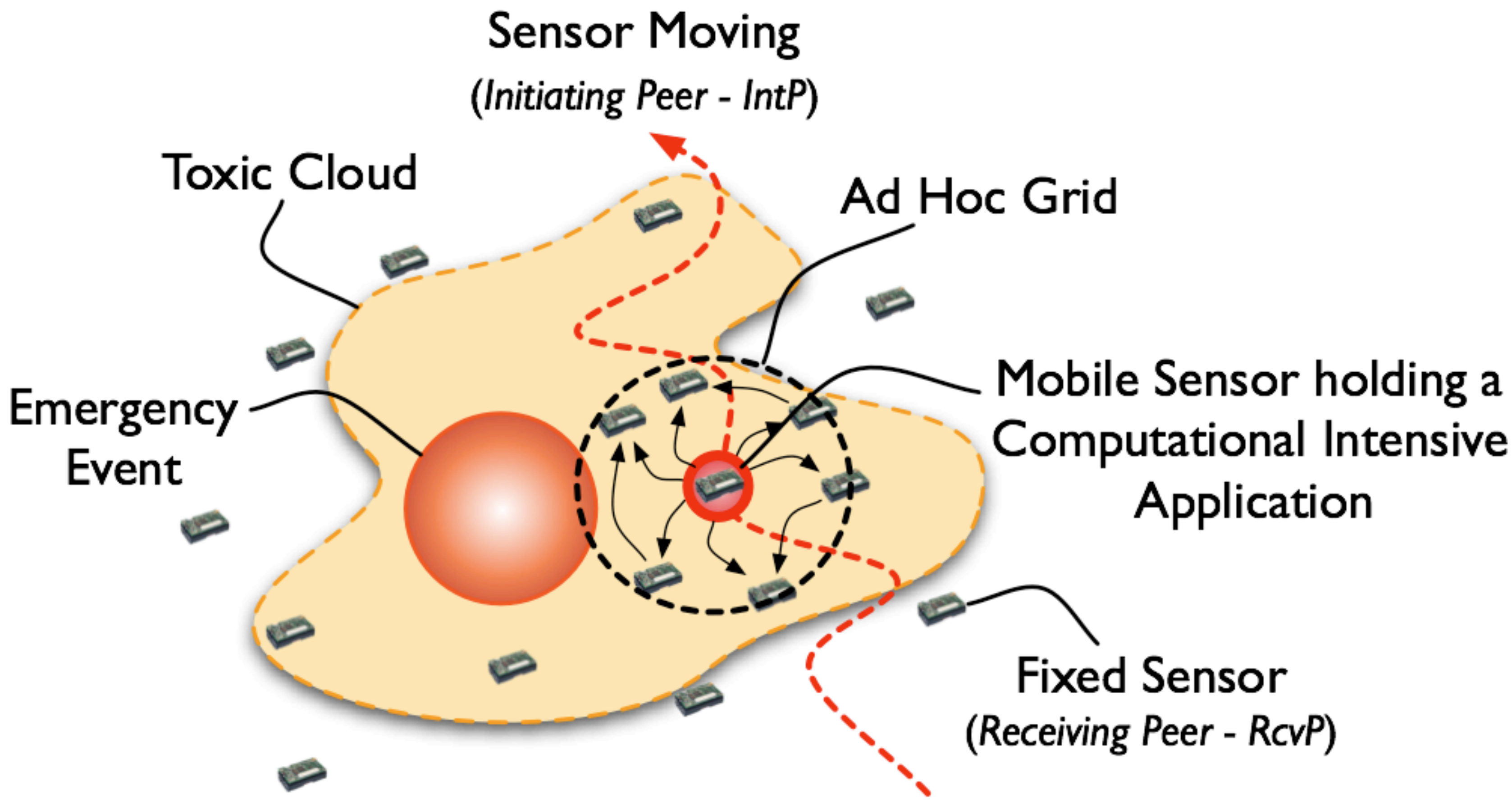
Overview

- Scenario
- MP2P WSN Paradigm
- The Bandwidth Problem
- MP2P Load Distribution
- Experimental Evaluation
- MP2P Systems Implications
- Conclusion and Future Work

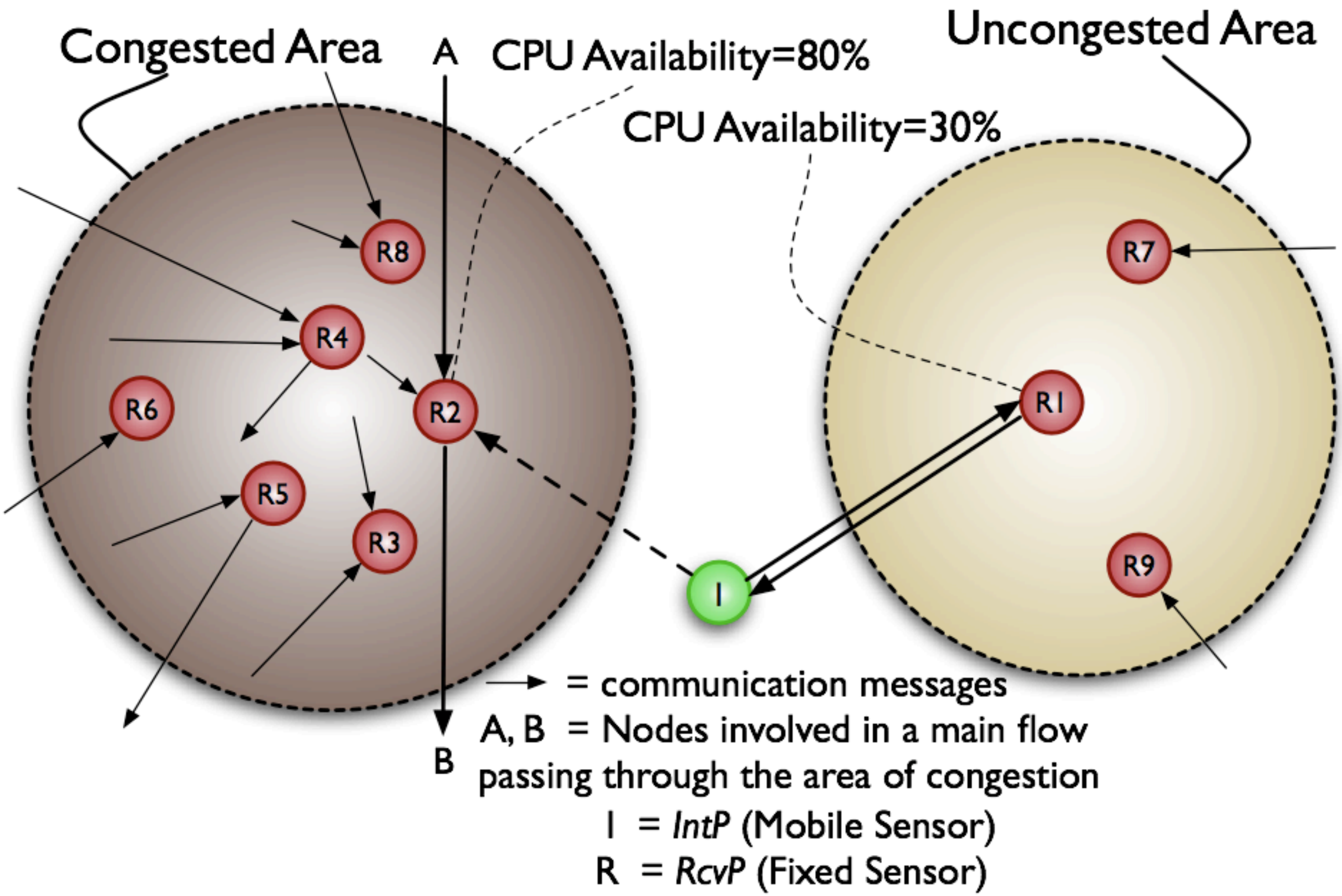
Emergency Scenario

- Emergency event (CBRE).
- Indoor environment (e.g. building or highly frequented public space).
- Dangerous for first responders to explore the area.
- Need for fast environmental information gathering.
- Timely information provision (e.g. first responders location, threat epicentre, rescued people, etc.) to external agencies.

MP2P WSN Paradigm



The Bandwidth Problem



Objective

Explore the problem of resource constraints in MP2P WSNs, experimentally evaluating the effects of taking into account ***local network conditions***, together with nodes' ***computational capabilities***, during load distribution.

MP2P Load Distribution

- Selection and adaptation of two load sharing algorithms to take into account both computational (CPU) and communication (bandwidth) requirements:

  - *Auction Algorithm* (sender-initiated/reactive).

  - *Lookup List Algorithm* (receiver-initiated/proactive)*.

- Definition of an *Utility Function* for the best candidate node selection.
- Evaluation on real Tmote Sky large-scale sensor testbed.
- Performance metric: average job execution time.

**P. J. Chuang, C.W. Cheng.* On File and Task Placements and Dynamic Load Balancing in Distributed Systems. *Tamkang Journal of Science and Software Engineering 2002.*

Utility Function

Parameters:

- i = Neighbour of a *IntP* ($i=1, ..., N$)
- N = Number of a *IntP* neighbours
- $C(i)$ = CPU availability of neighbour i
- $B(i)$ = Bandwidth availability of neighbour i
- $S(i)$ = Score of neighbour i
- w_C = Weight CPU
- w_B = Weight Bandwidth

$C(i)$ = *number of active processes.*

$B(i)$ = *historical information of the last N temporal time slots in which the radio channel was clear or busy (reading Clear Channel Assessment from CC2420).*

$$S(i) = w_C * C(i) + w_B * B(i)$$

Best Candidate ➡

$$S_{max} = \max_{i=1, ..., N}\{S(i)\}$$

HEN Sensor Testbed

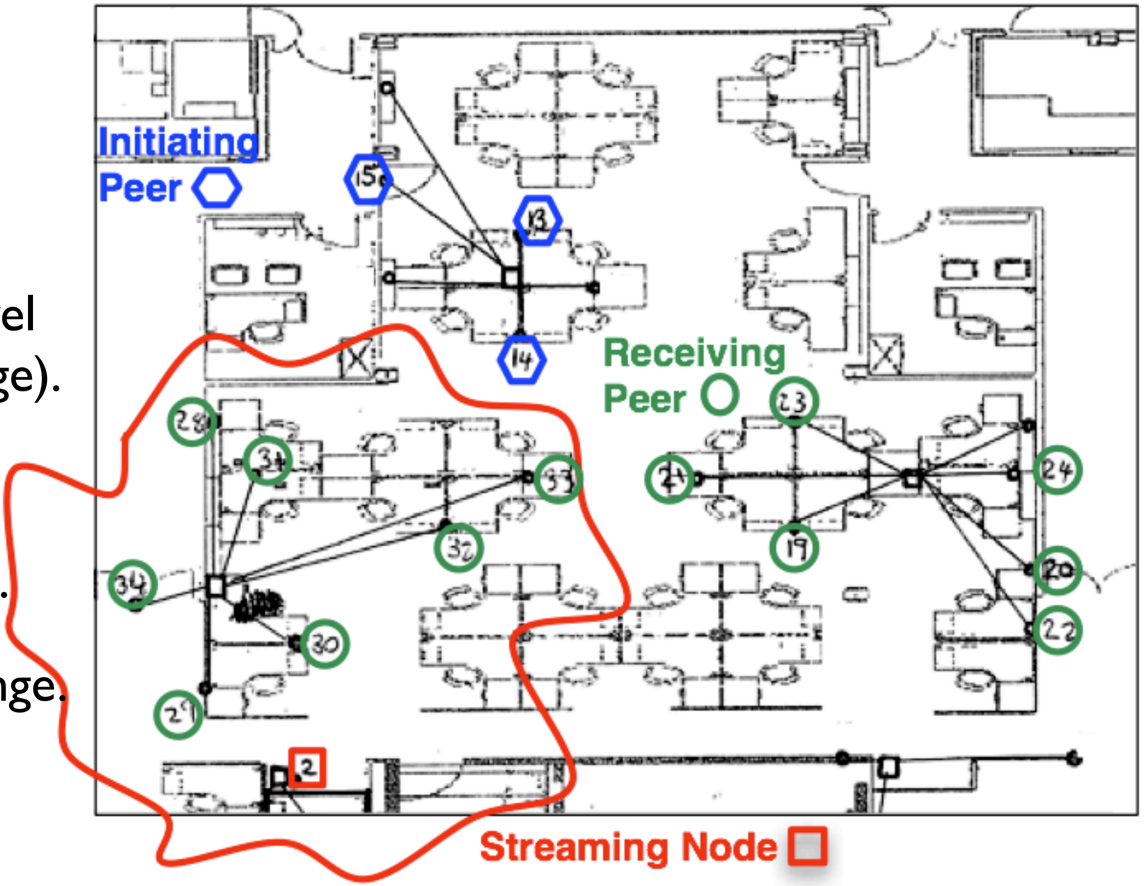
Heterogeneous Experimental Network (HEN)

http://www.cs.ucl.ac.uk/research/hen/

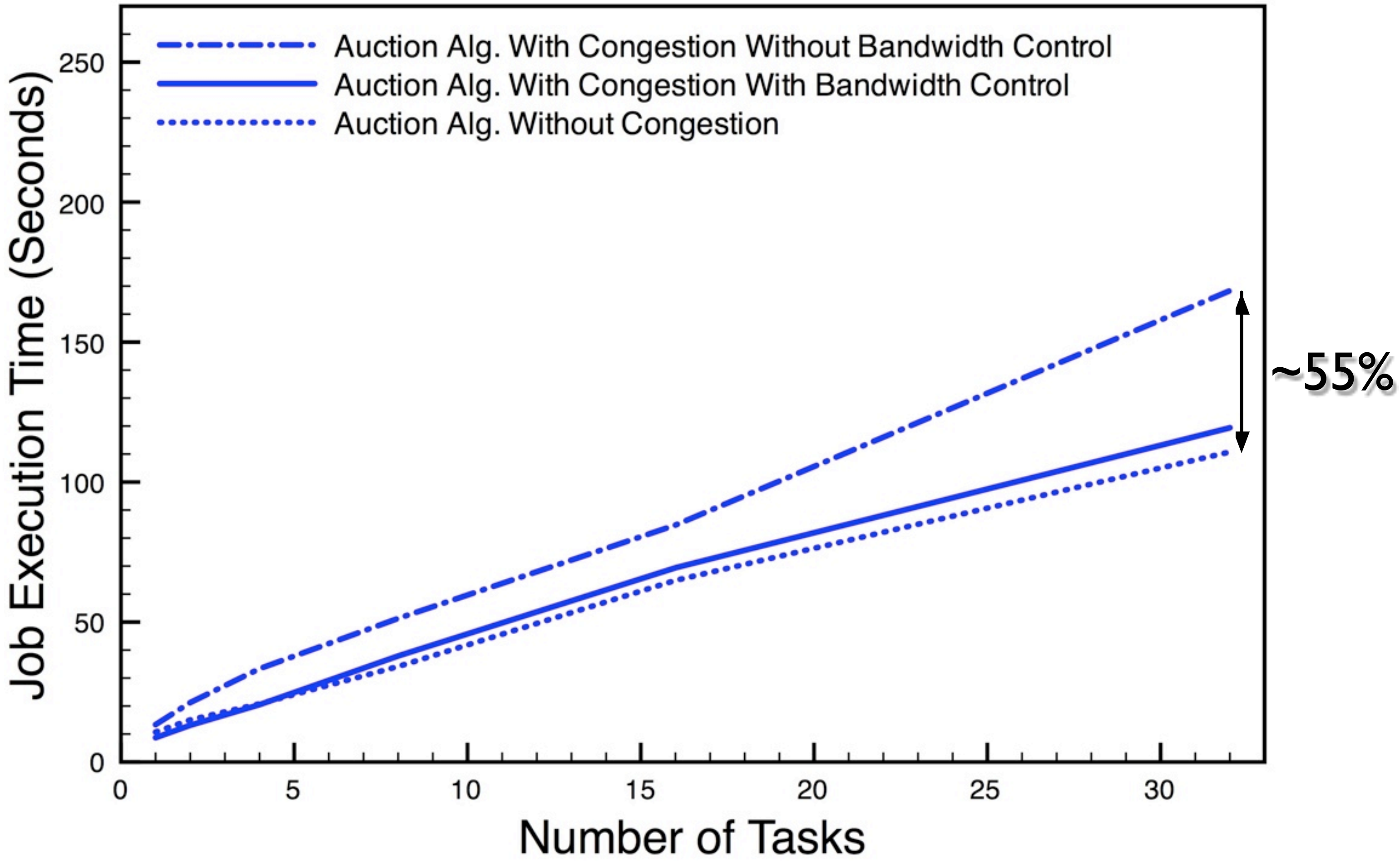
- 40 Tmote Sky Sensors
- Random Deployment
- Remotely Accessible
- Remotely Programmable
- Fast Kernel Flashing
- Contiki OS and TinyOS

Experiment A

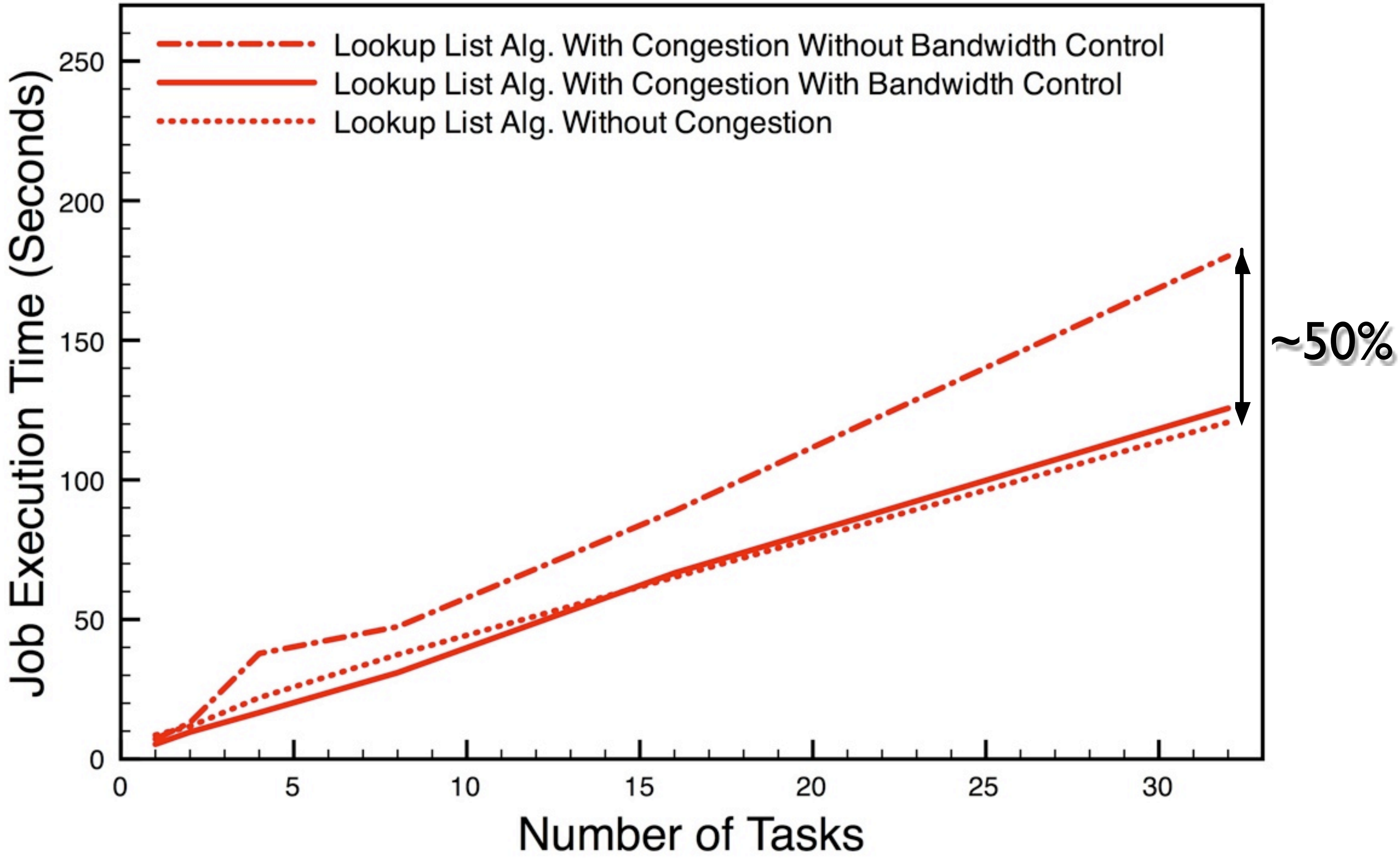
- 3 *IntPs* and 21 *RcvPs.*
- 1 Streaming node.
- Streaming radio power level 0x03 (~250cm packet range).
- Job formed by 32 tasks.
- 50 Offload/upload packets.
- UDP/TCP message exchange.
- Contiki OS.



Experiment A - Auction

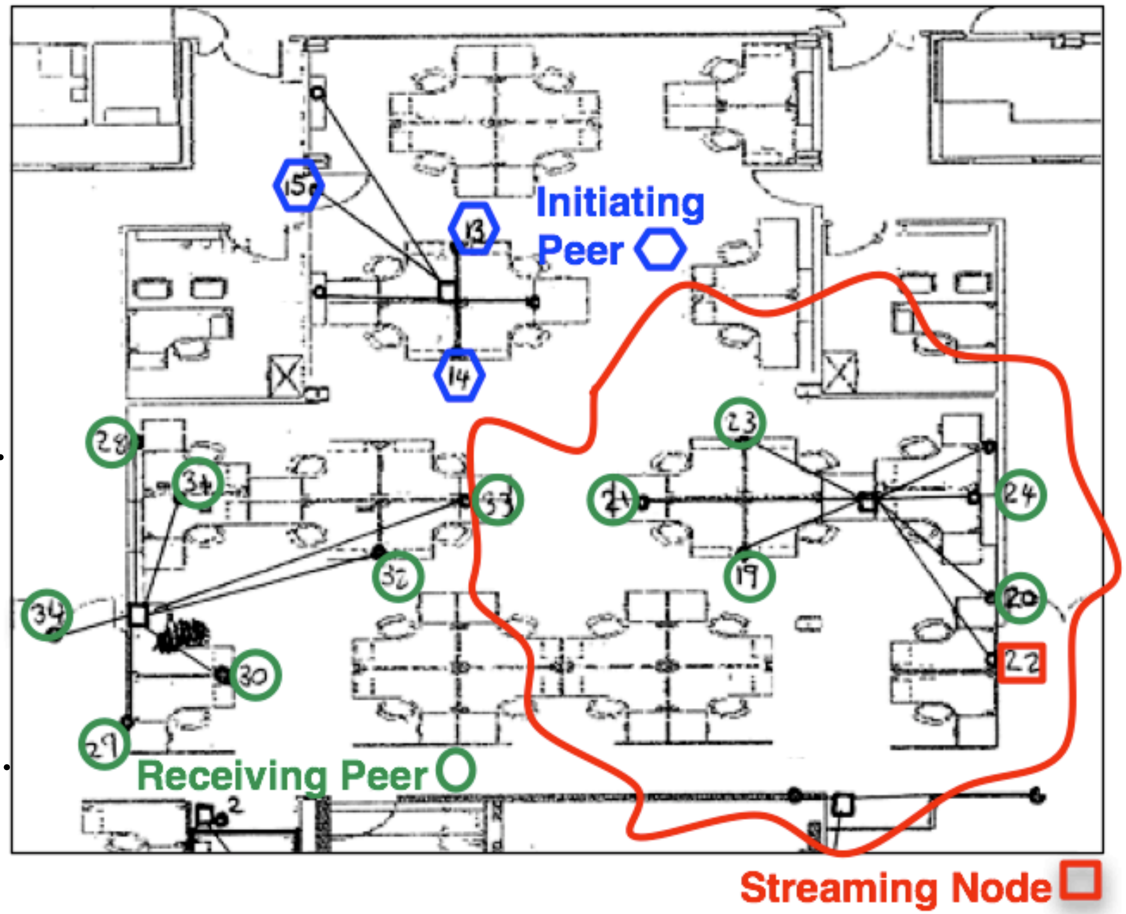


Experiment A - Lookup List

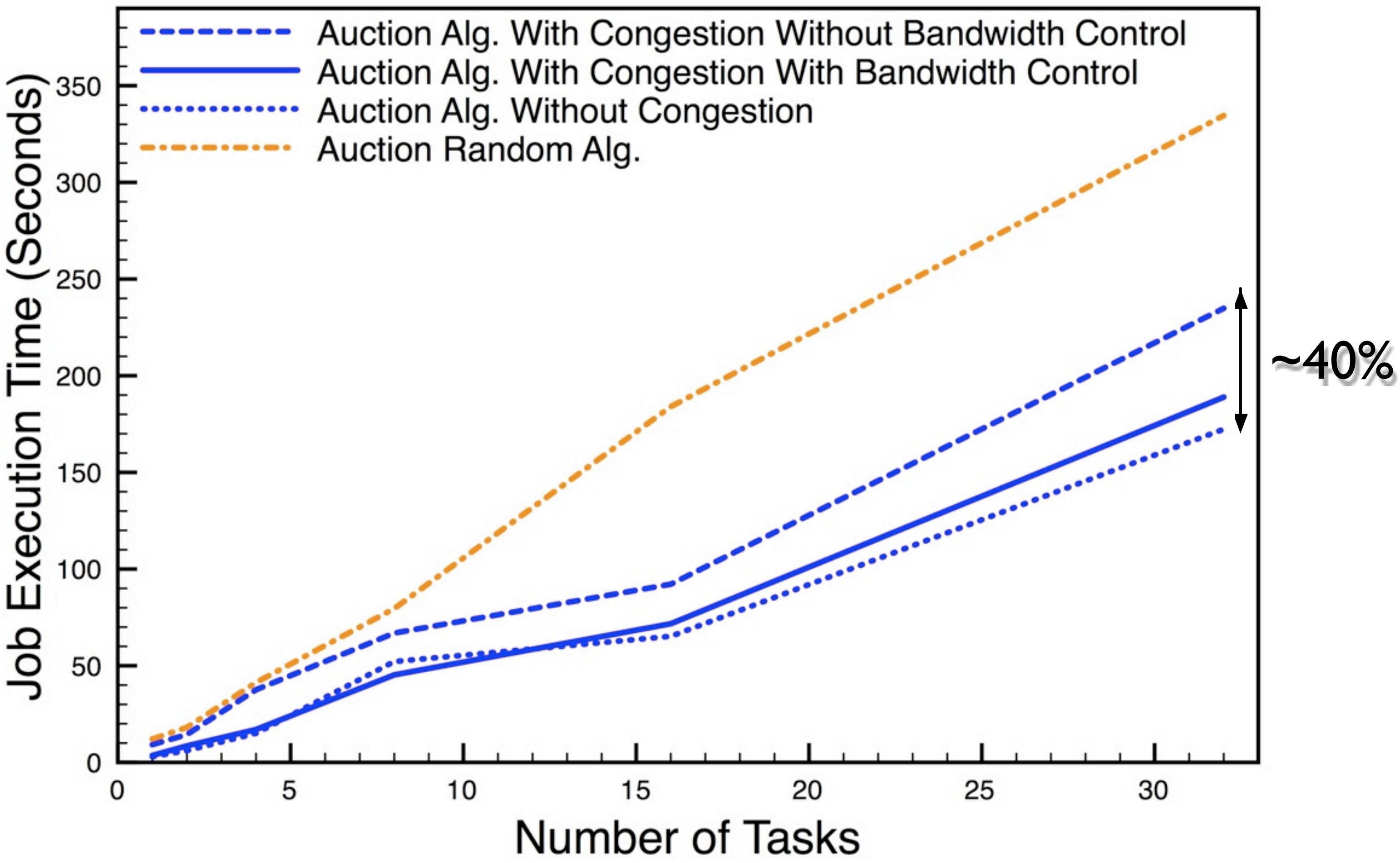


Experiment B

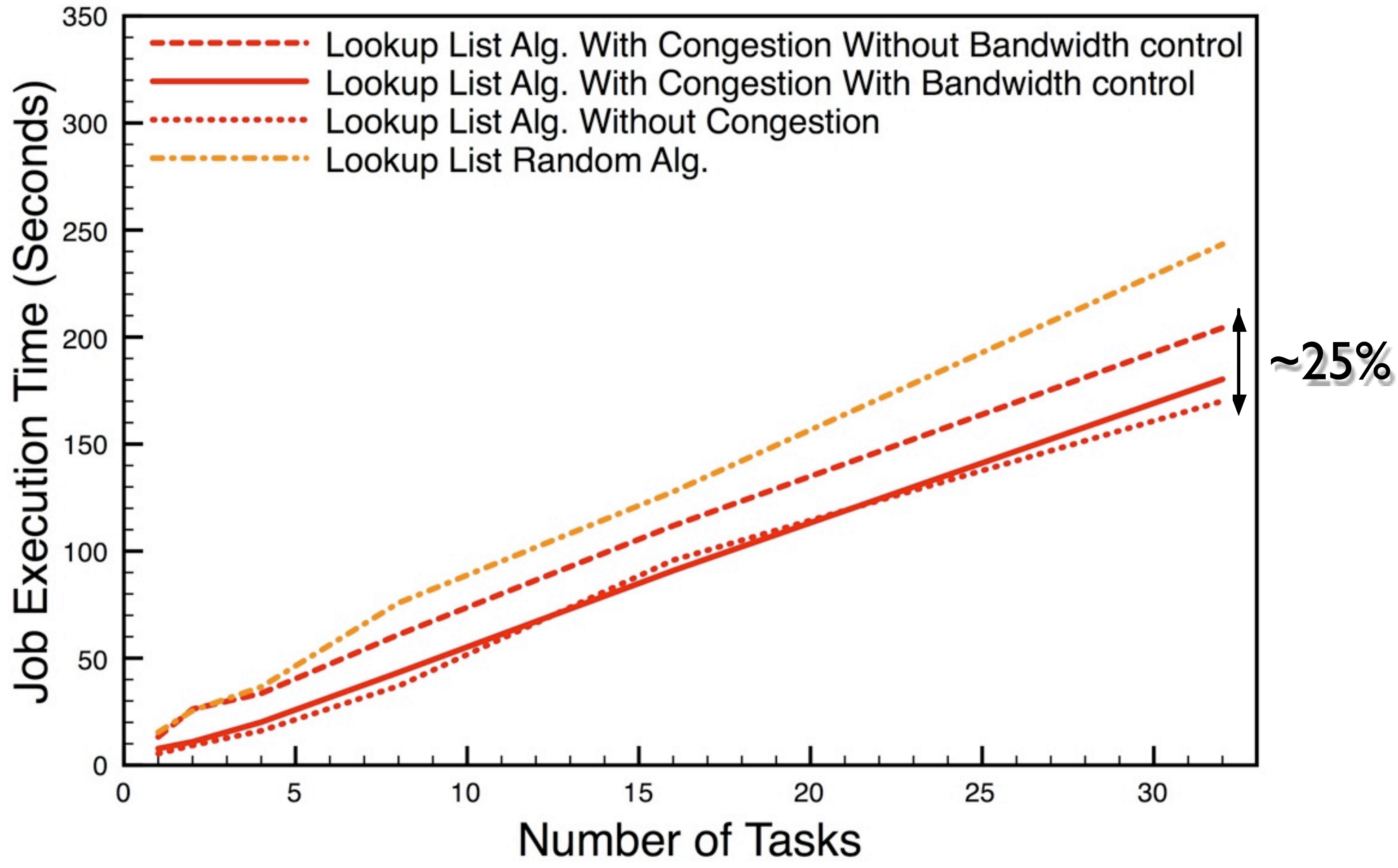
- 3 *IntPs* and 21 *RcvPs*.
- 1 Streaming node.
- Streaming radio power level 0x03 (~250cm packet range).
- Job formed by 32 tasks.
- 50 Offload/upload packets.
- UDP/TCP message exchange.



Experiment B - Auction



Experiment B - Lookup List



MP2P Systems Implications

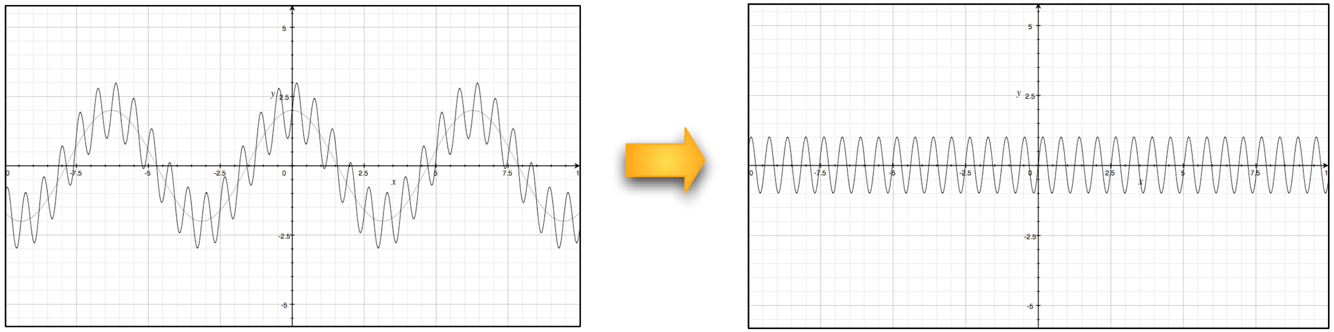
- Information about the underlying radio conditions is available to the task distribution process:
  - by adopting a ***cross-layered approach*** using an API to allow the application overlay to access low level details;
  - by inferring approximate information about the physical state of the network through tests performed ***without layer violation***.

The greatest challenge for MP2P WSN systems is to utilise ***only*** *information available at the application overlay to infer congestion levels.*

MP2P Systems Implications (II)

Two effects act on the **latency** of a path:

- ***Length/number of hops*** of a path underlying a logical links (lower frequency).
- Variability in the ***path quality*** resulting from congestion (higher frequency).



Suggestion:

- From latency measurements, a Hamming FIR-H filter can separate the short timescale congestive effect from the longer timescale effects of changing path length.
- More effective estimate of bandwidth availability respecting both can be created.

Conclusions

In MP2P WSNs:

- Physical network conditions have a major impact on the performance of job collaborations between peer nodes.
- Simple load sharing algorithms can be adapted to take into account *both* computational capabilities *and* network conditions improving system performance.
- Cross-layered or heuristic approaches applied at the application overlay need to gather network parameter and use them within the load sharing algorithms.

In future:

- We plan to study techniques providing effective bandwidth estimation at the application overlay of MP2P WSNs without layer violation.

Thank you!

... questions?