

Adaptive Data Transport and Management for Wireless Sensor Networks

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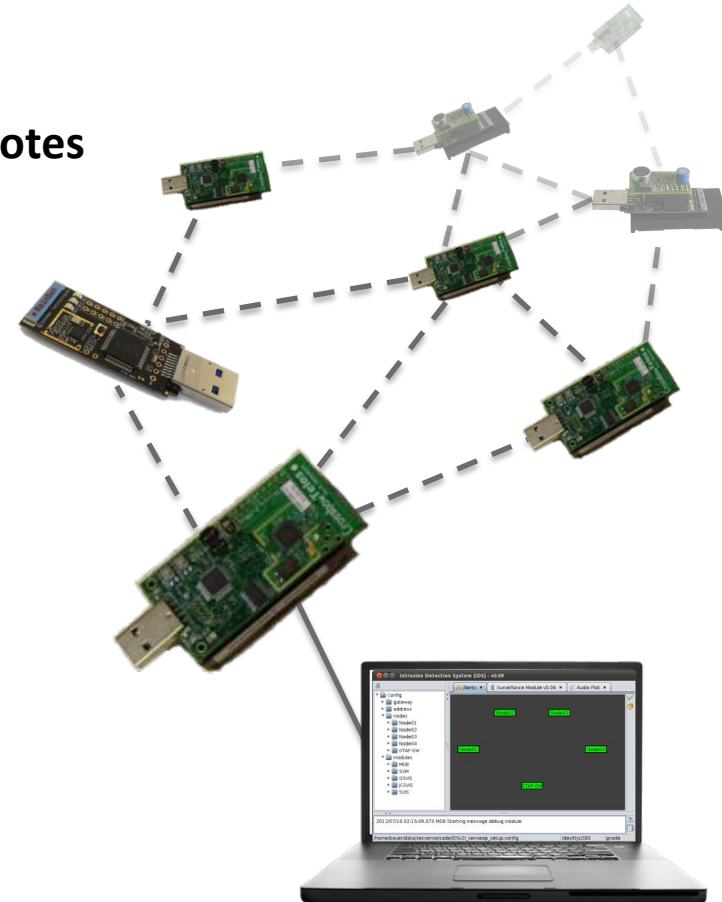
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Outline

- **Introduction & Motivation**
- **Sensor Data Transport and Management**
- **First Evaluation Results**
- **Conclusion**

Wireless Sensor Networks

- plurality of small, cost-effective sensor nodes
- wireless multi-hop communication
(IEEE 802.15.4)
- distributed manner
- self-organizing
- long-term deployments
- task:
monitoring of physical measurable phenomena



Challenges:

- restricted resources
- dynamic network topologies
- heterogeneity

Application Areas

- Precision Farming



energy efficiency

Smart Factory



reliability & security

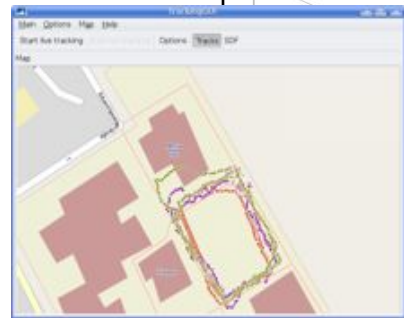
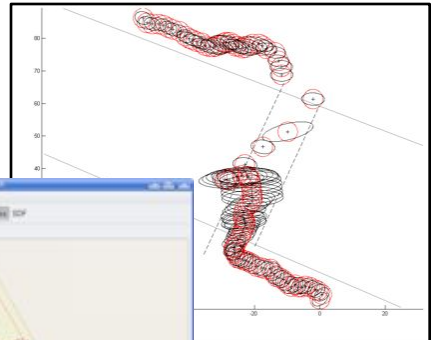
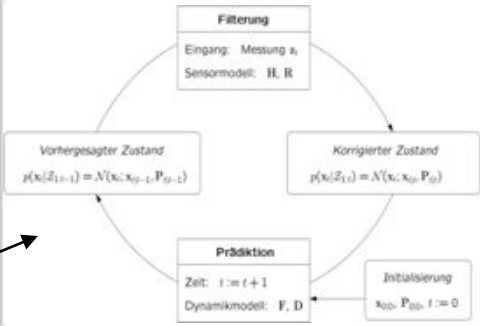
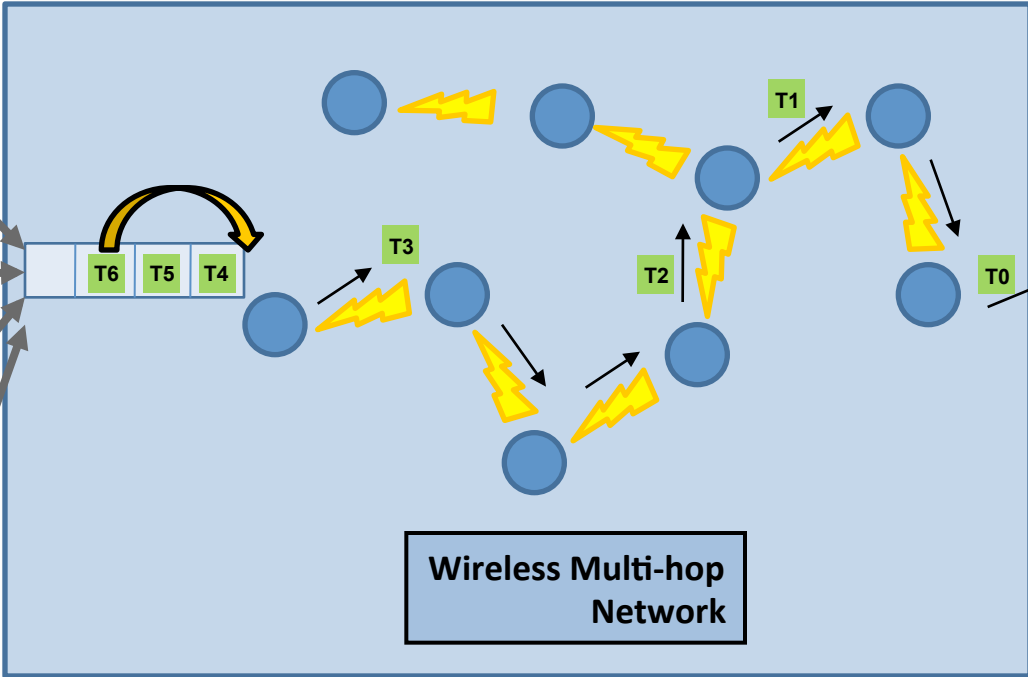
Public Safety



self-organization & mobility

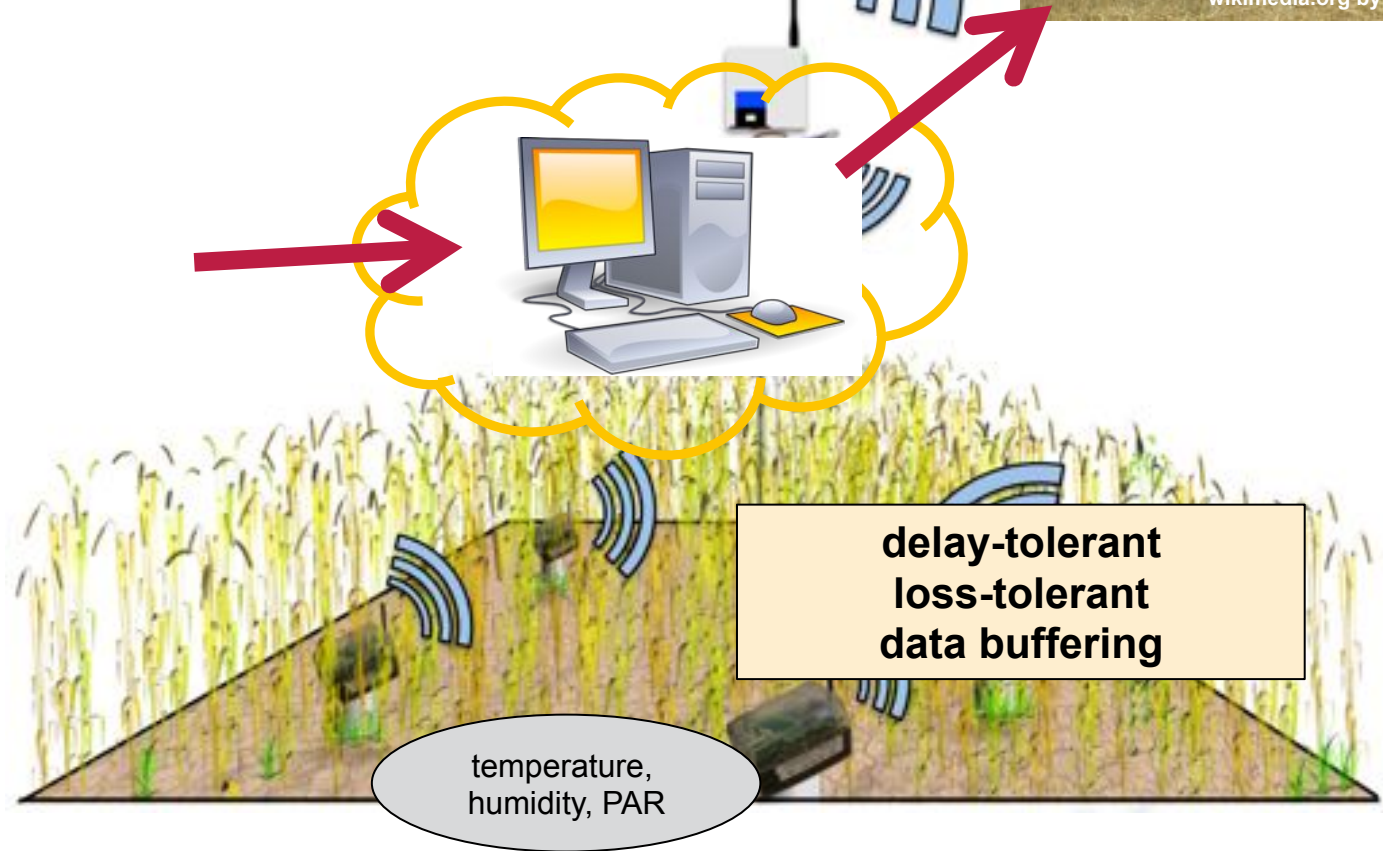


GPS

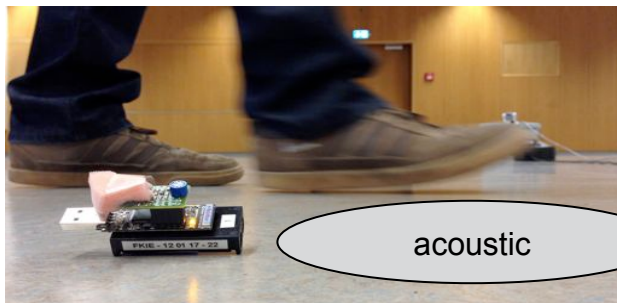
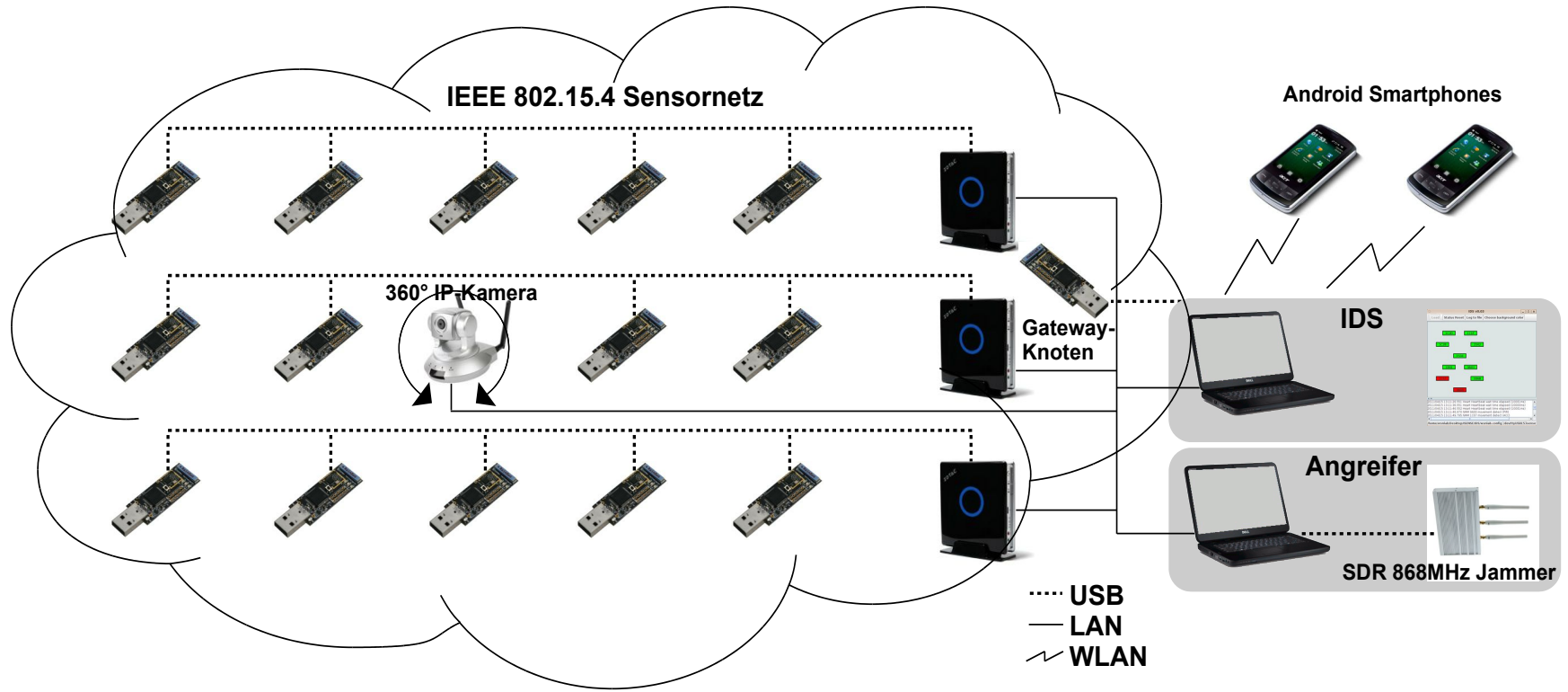


- Losses
- Delays
- Packet Reordering
- Disruptions

Motivation: In-situ Crop Monitoring in Precision Farming Scenarios



Motivation: Surveillance of Critical Infrastructure (SecSense)



acoustic

**real-time sensitive
reliable**



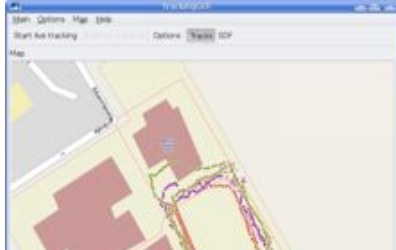
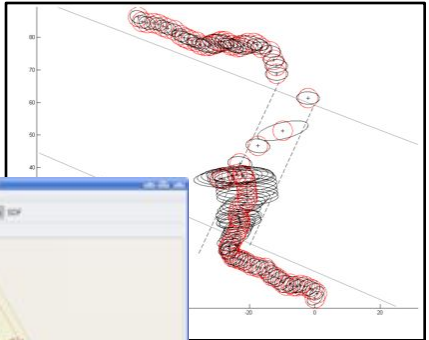
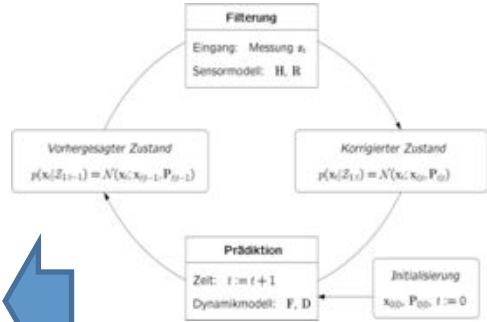
GPS



Application Requirements

- **timeliness:** real-time sensitive vs. delay-tolerant
- **completeness:** reliable vs. loss-tolerant
- **reordering:** out-of-sequence tolerance
- **buffering:** dropping vs. queueing
- **prioritization**

- Losses
- Delays
- Packet Reordering



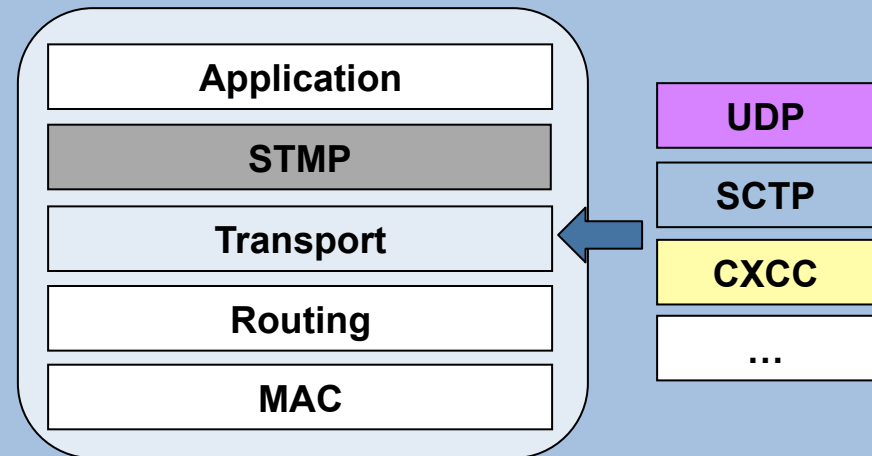
Adaptive Sensor Data Transport and Management

STMP

Sensor data Transmission and Management Protocol

Design Principles:

- Small protocol overhead
- Flexible for different requirements of:
 - Sensors
 - Network
 - Fusion Algorithm
- Extensible for future features
- Disruption tolerant



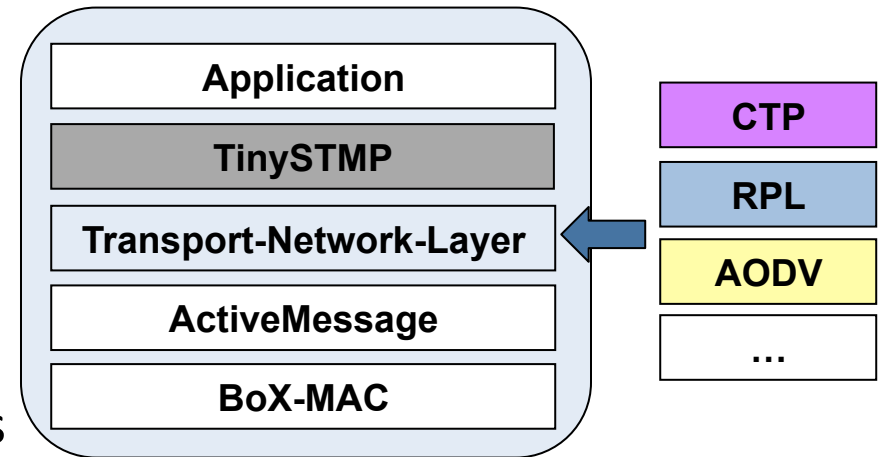
Features in current Specification:

- Server Discovery
- Sensor Re-/Deregistration
- Stream Identification
- Timestamping in variable precision
- Stream Prioritization
- Data Prioritization
- Controlled Loss
- Keep Alive

Nils Aschenbruck, Christoph Fuchs: "STMP - Sensor Data Transmission and Management Protocol"
Proc. of the 36th IEEE Conference on Local Computer Networks, LCN, Bonn, Germany, Oct. 4–7, 2011.

Challenges of WSN-Adaptation

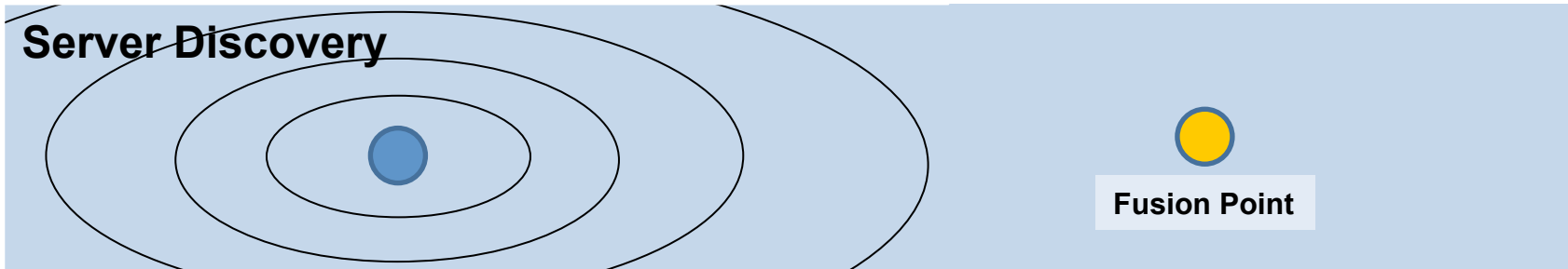
- restricted resources
- fuzziness of OSI Layers
- no dynamic memory allocation
 - fixed queue sizes
 - fixed number of priority classes



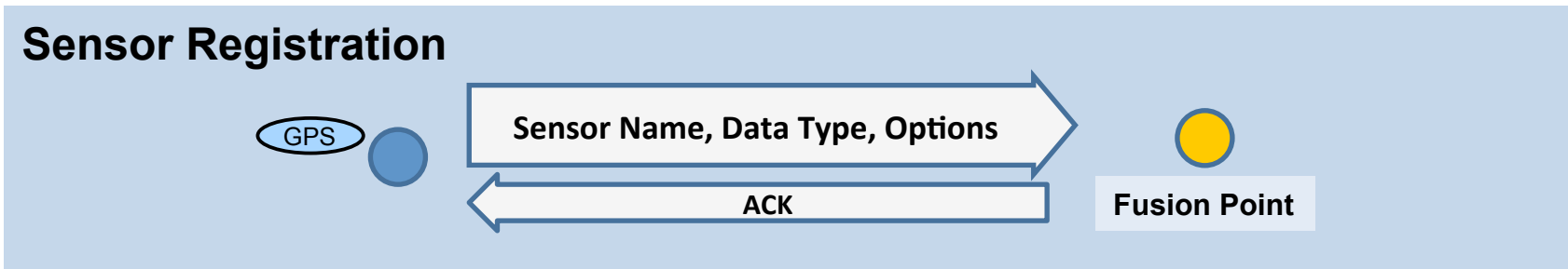
Memory Footprint (TinyOS, GNode Platform)

	ROM		RAM	
	(kB)	(%)	(kB)	(%)
default	16.038	13.8	6.238	78
minimal	16.022	13.8	3.244	40.5

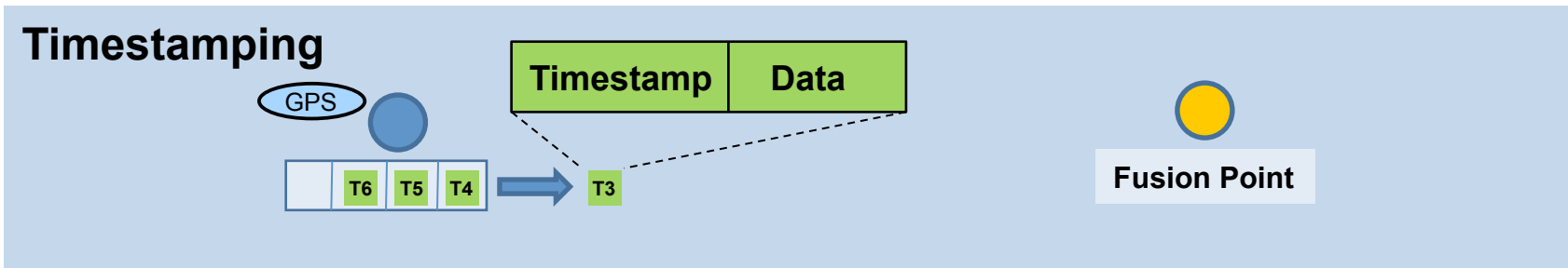
Server Discovery



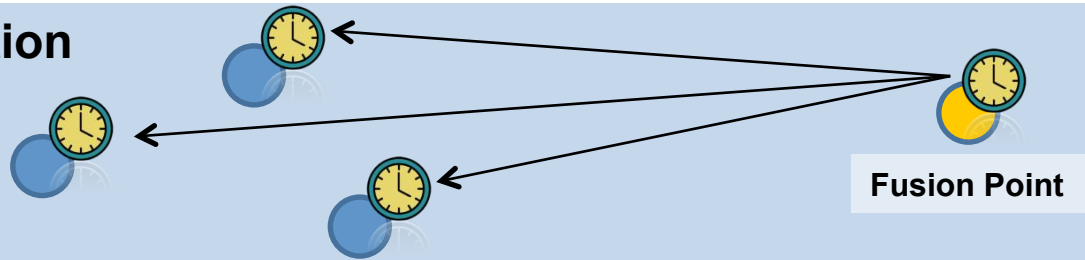
Sensor Registration



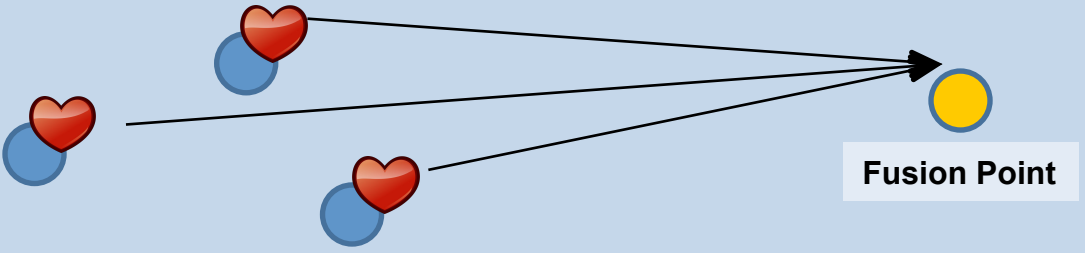
Timestamping



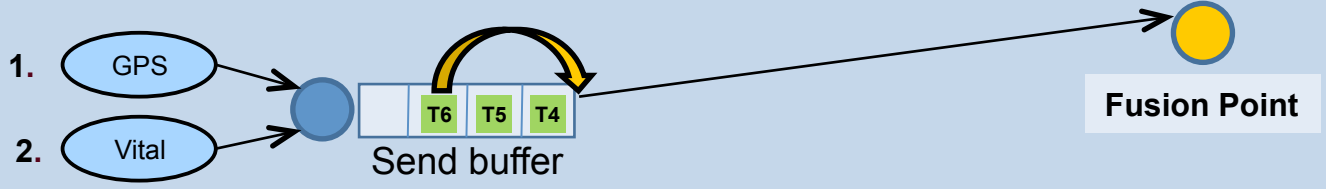
Synchronization

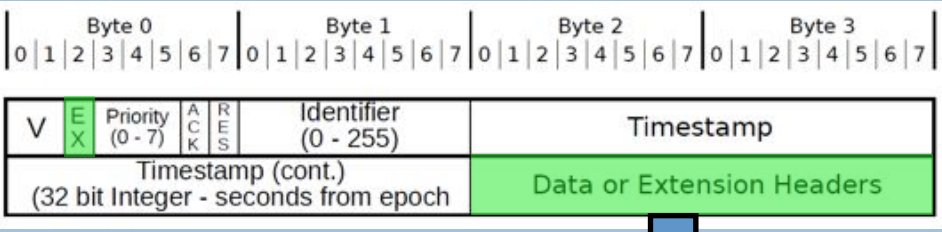


Keep-Alive



Prioritization





STMP Extension Headers:

No Next Header: (Data)	0				
Milliseconds:	1	2 bytes			
Microseconds:	2	4 bytes			
Sequence Number:	3	2 bytes			
Sensor Registration:	4	Sensor Type (2 bytes)	Sensor Name (20 bytes)	Compression (1 byte)	Encryption (1 byte)
Sensor Deregistration:	5				
Registration Error:	6				
Keep Alive:	7				
Timesync Request:	8				
Timesync Reply:	9	Request sendtime (4 bytes)			
Length:	10	Length in byte (2 bytes)			

Extension Headers are used for:

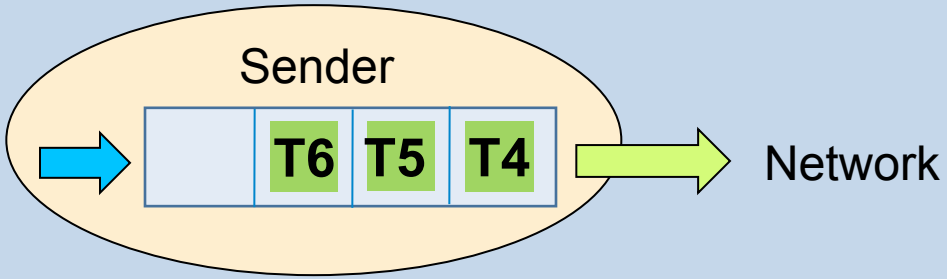
- Infrequent Operations
 - Registration
 - Synchronization
 - Keep Alive
- Advanced Features
 - Timestamp precision
 - Variable data length
- Future Extensibility

Sensor Management

Sampling Rate:	11	4 Byte
Sleep Interval:	12	4 Byte

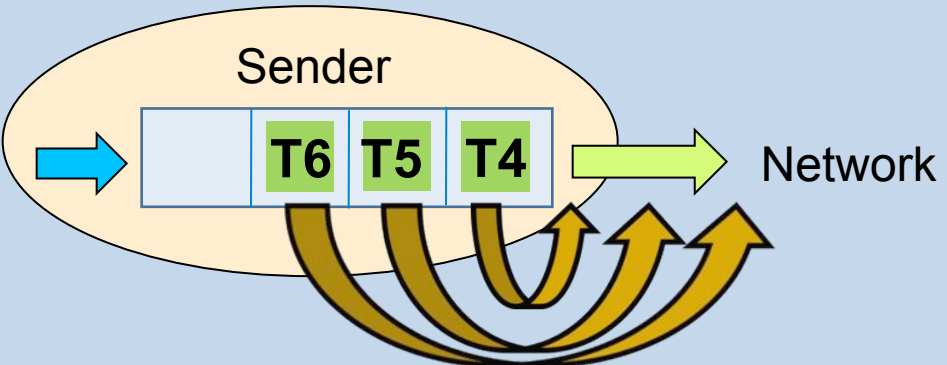
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Normal Buffers (First In First Out):



→ old packets are sent first

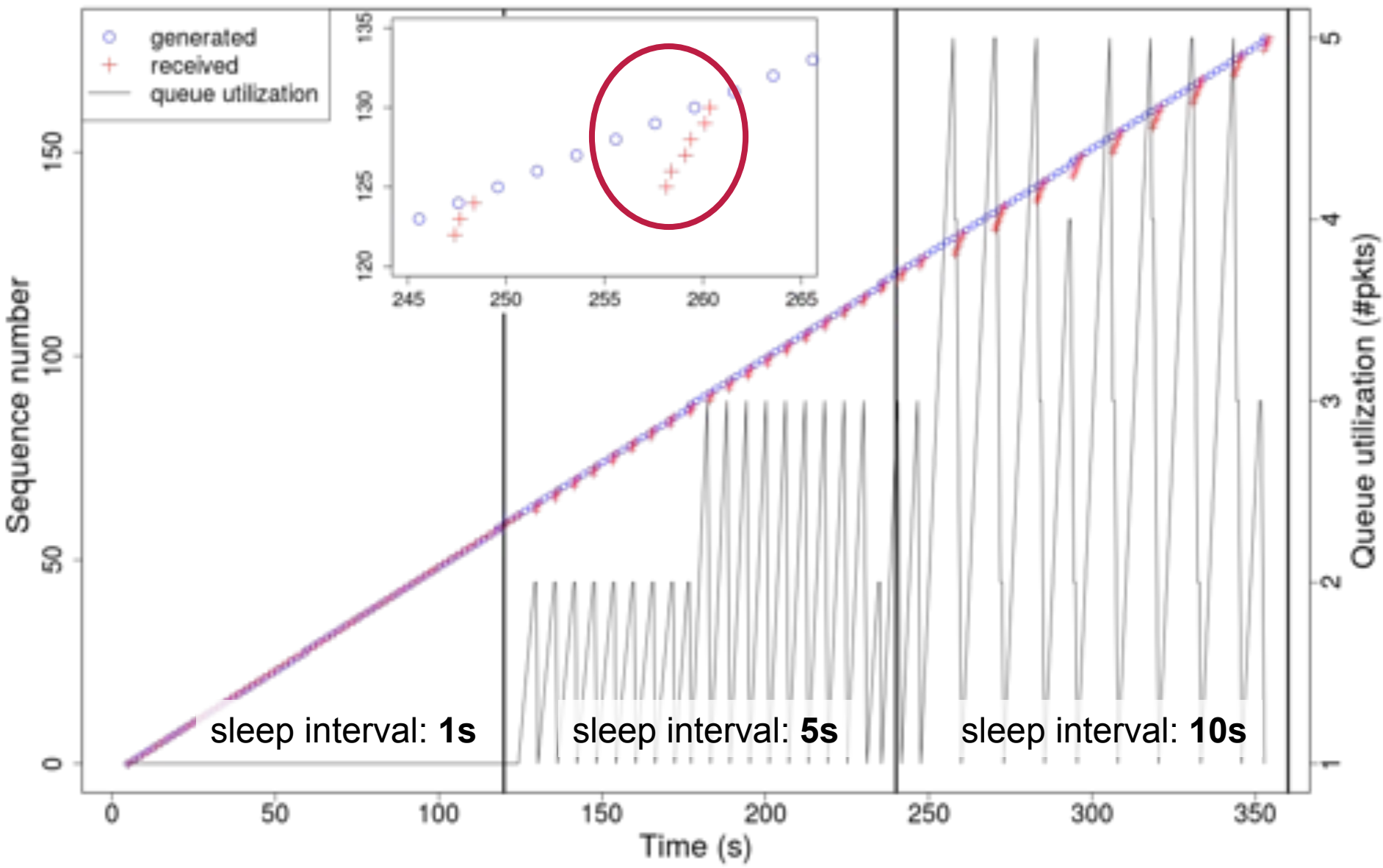
Last In First Out (LIFO):



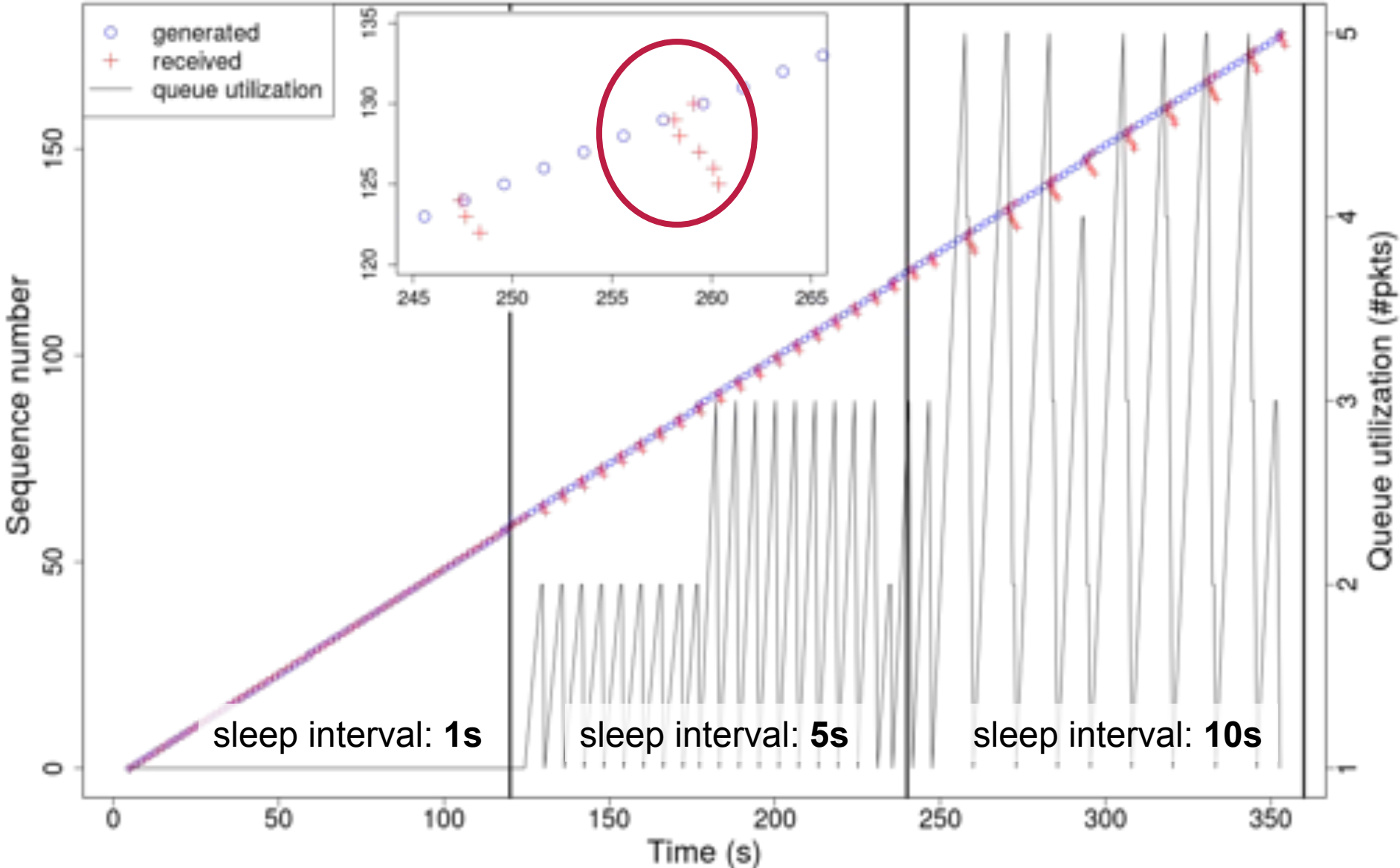
→ youngest packets are sent first

Evaluation Setup	
number of sensors	1
sampling rate	0.5 Hz
keep alive interval	20 s
synchronization interval	60 s
sensor queue length	10 pkts
sensor dequeuing rate	0.5 pkt/s
node queue length	20 pkts
Node dequeuing rate	0.5 pkt/s
variations:	
sleep interval	1, 5, 10 s
queueing strategy	FIFO, LIFO

Evaluation: FIFO-Queueing



Evaluation: LIFO-Queueing

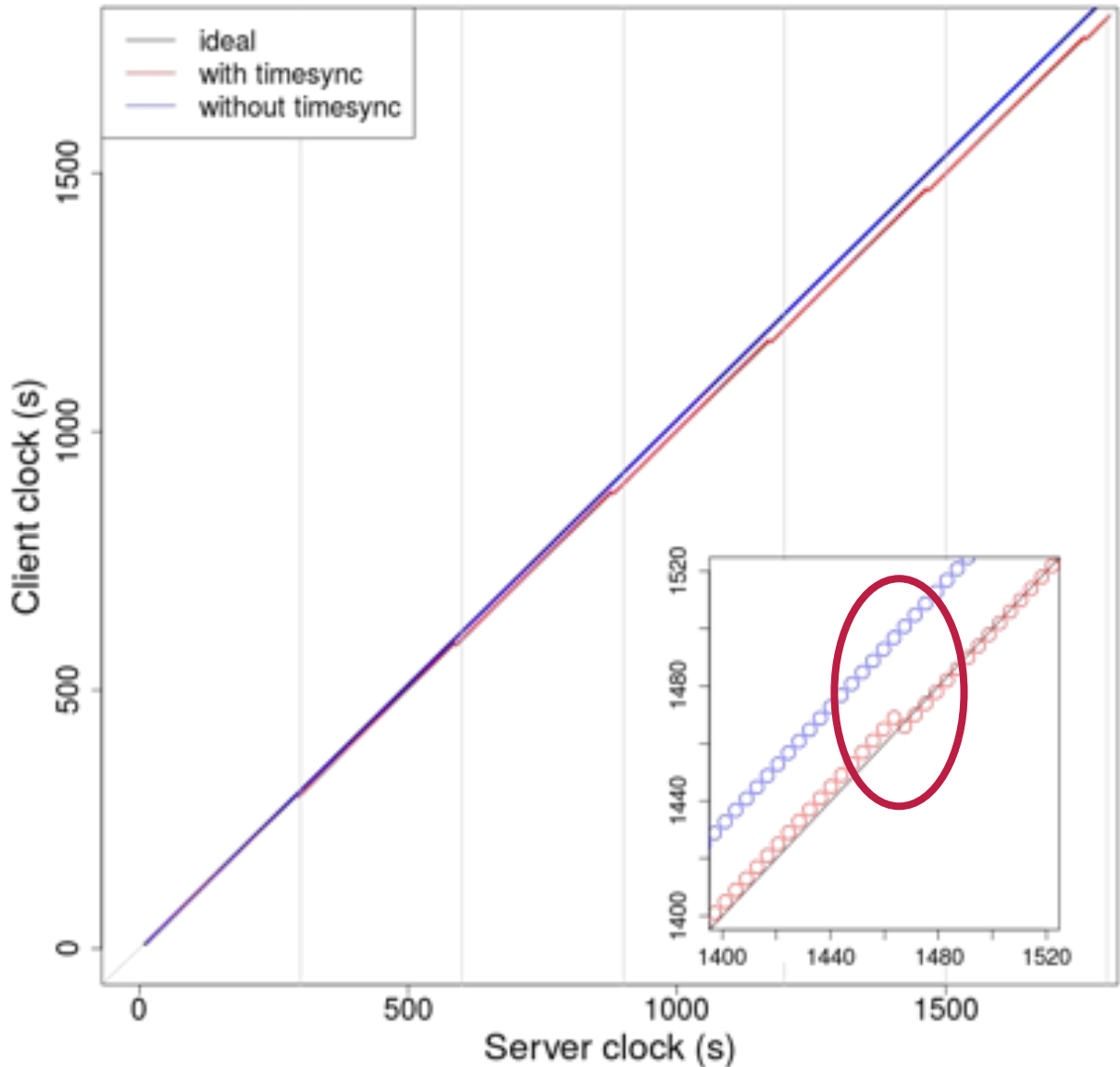


Evaluation: Impact of LIFO-Queueing on Situational Awareness



Evaluation: Time Synchronization Effect

Evaluation Setup	
number of sensors	1
sampling rate	0.25 Hz
keep alive interval	20 s
synchronization interval	300 s
artificial clock skew	1.024
sensor queue length	10 pkts
sensor dequeuing rate	0.5 pkt/s
node queue length	20 pkts
Node dequeuing rate	0.5 pkt/s
sleep interval	2 s
queuing strategy	FIFO



Summary

- characteristics of WSNs and applications requirements
- demand for Adaptive Sensor Data Transport and Management
- TinySTMP with first results

Future work

- further extensions of TinySTMP
 - prioritization management
 - in-network data aggregation
- integration of Routing/Transport-Protocols



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Thanks for your attention!

