# Could North Korea's 4,300 Tanks Crush America in a War?

Dave Majumdar

The National Interest October 16, 2017

# Will Flood of Weinstein Accusers Bring Sweeping Change to Hollywood?

by CLAIRE ATKINSON

# Has Social Media Become Worse than Slavery?

| Date | Views | By | |
|---|---|---|---|
| September 19, 2017 | 2803 | M Green | 8 Comments |

THE A.V. CLUB HOSTED BY JOHN TETI

# ARE THERE SITCOMS ON MARS?

Health News

# Could homeopathy help to tackle the H1N1 virus?

## Will the Blockchain make art disappear?

J.J. Charlesworth

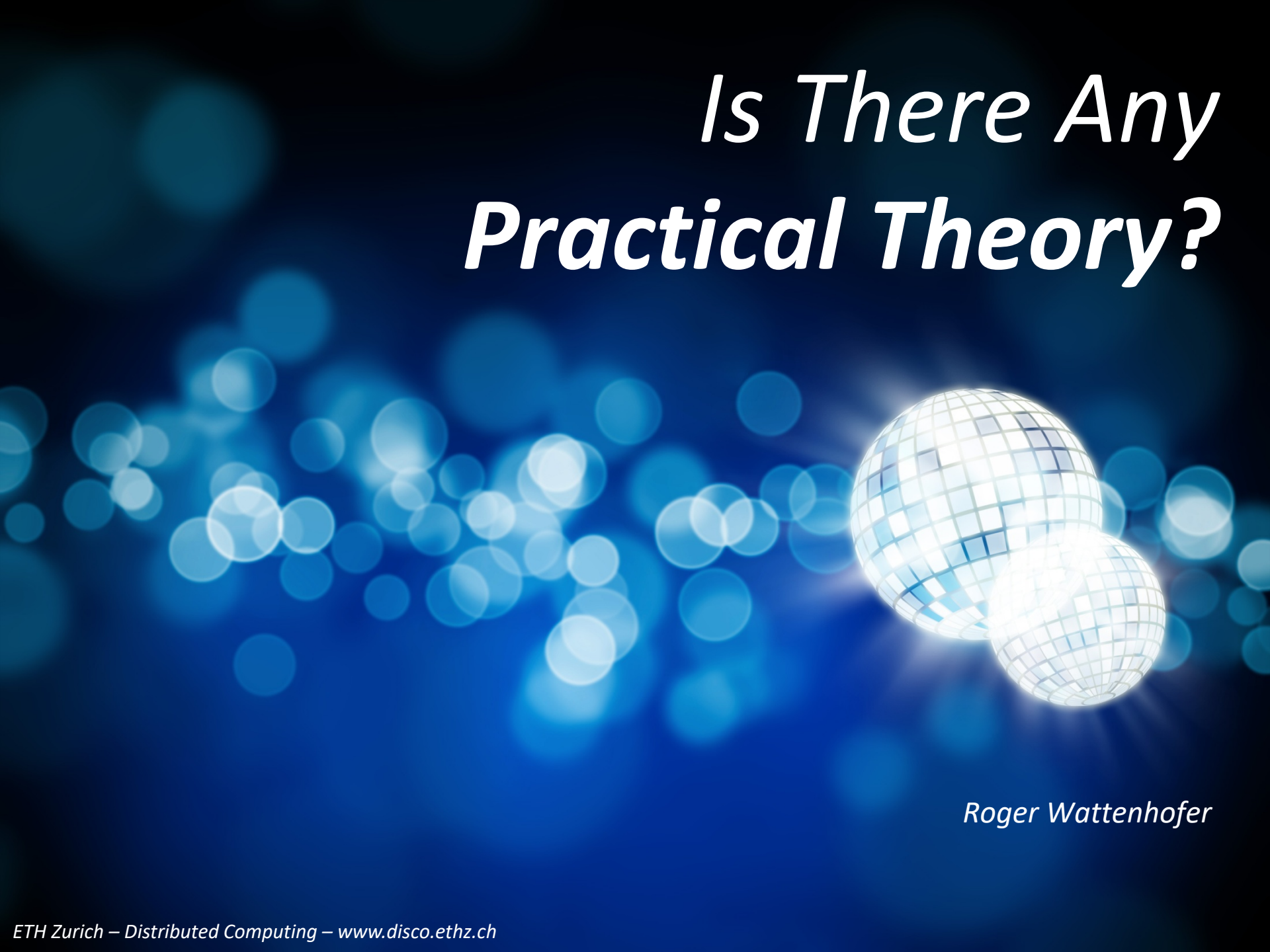
## Does Topology Control Reduce Interference?*

Martin Burkhart, Pascal von Rickenbach, Roger Wattenhofer, Aaron Zollinger
Department of Computer Science
ETH Zurich

No.

(Betteridge's Law of Headlines)

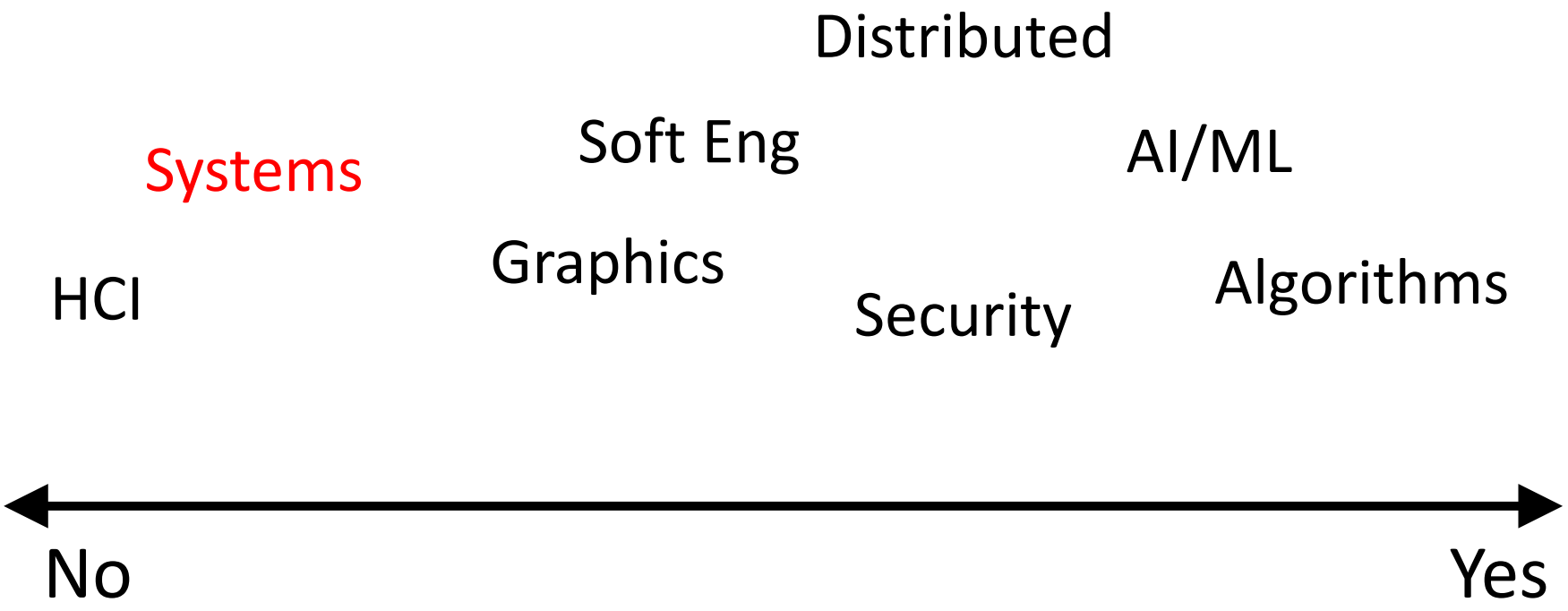
# *Is There Any* ***Practical Theory?***



*Roger Wattenhofer*

# Theory & Practice

# Theory Meets Practice?

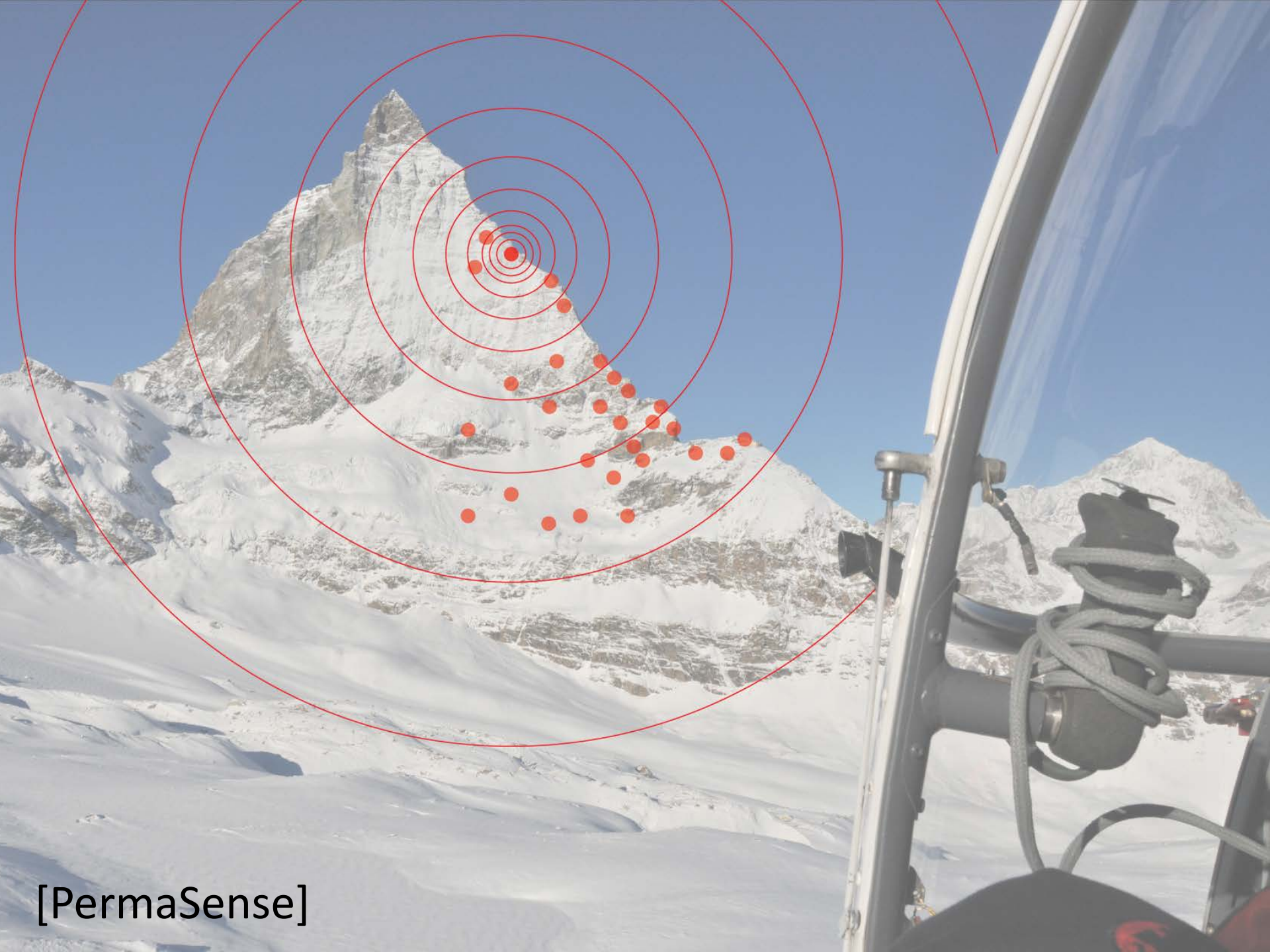



[Just my personal observation]

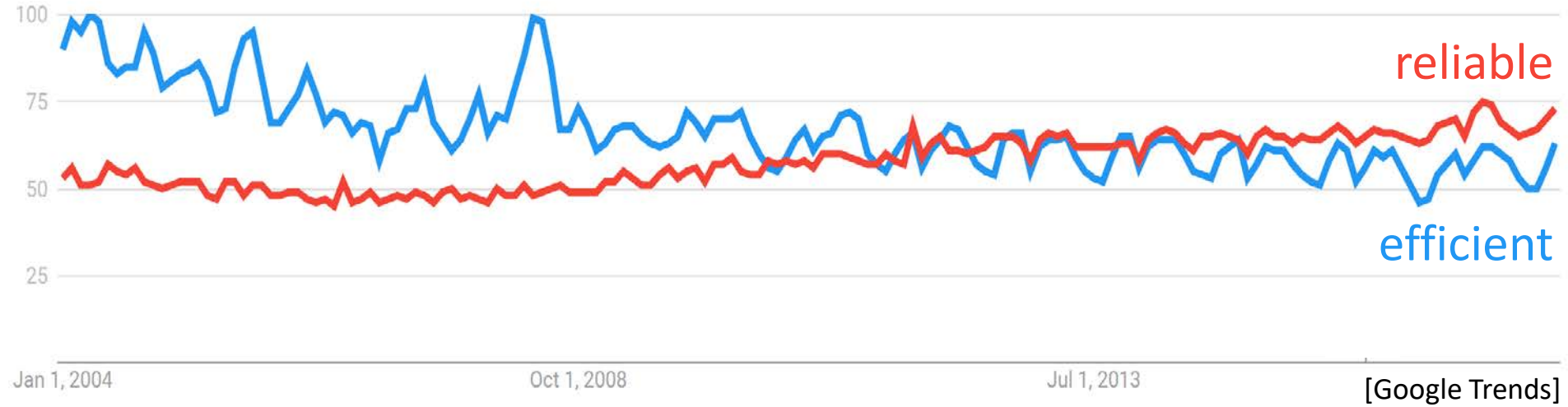
# Sensor Networks

# Data Gathering

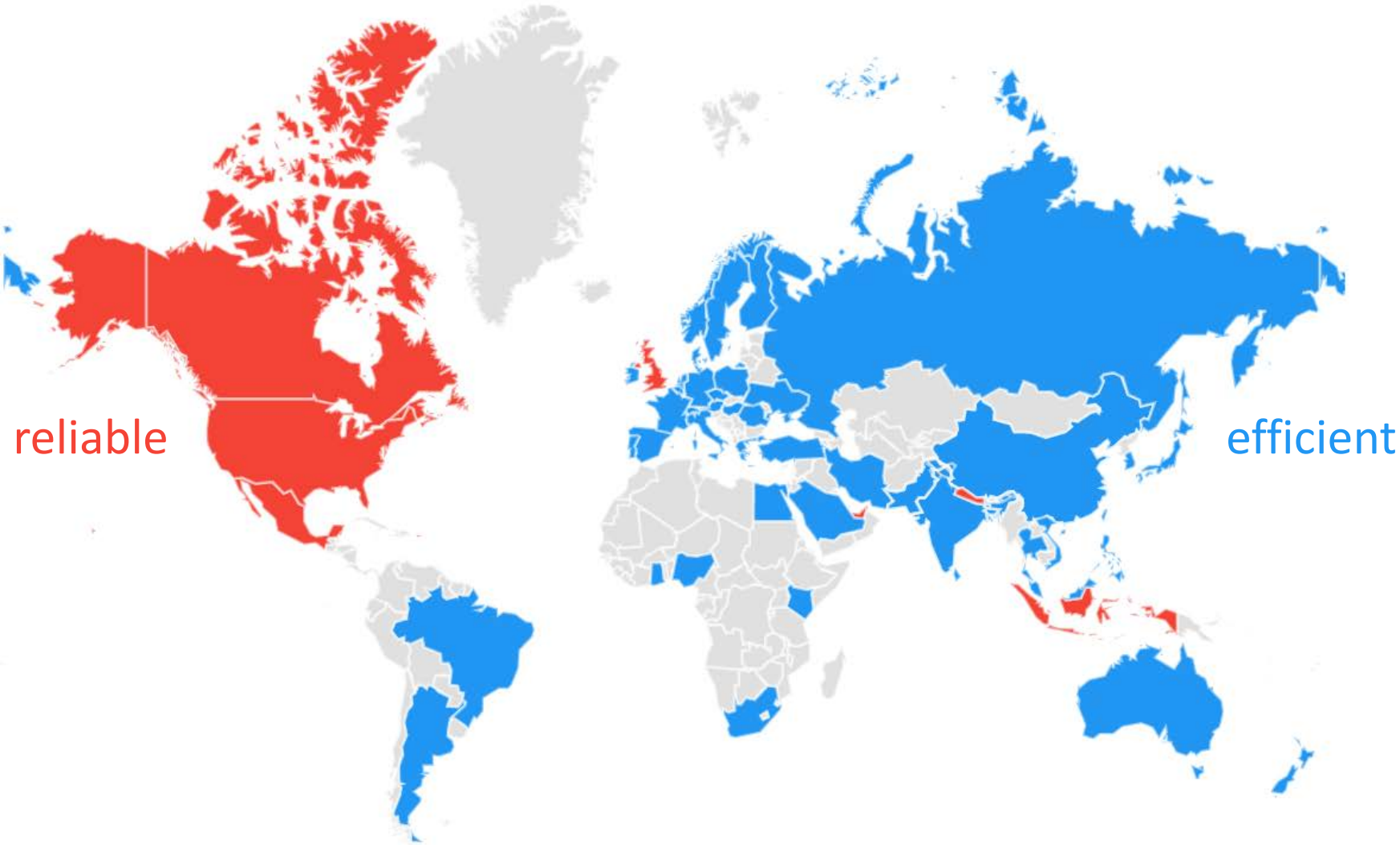
*Roger Wattenhofer*


[PermaSense]

# Efficiency and Reliability




[Google Trends]




[Google Trends]

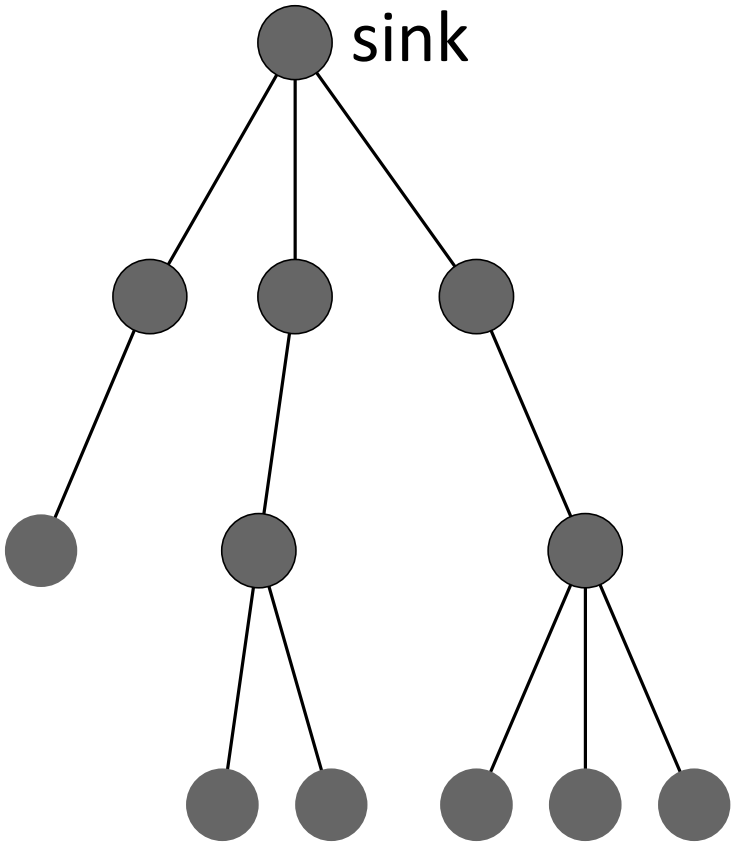
“This paper does a great job at a complete cross-layer design spanning the MAC, link, routing, and application layers to achieve very low power and high reliability for data collection. In some sense this is the first paper I'd give someone working on communication in sensor nets, since it nails down how to do it right.”

[Matt Welsh, Best of CS 263]

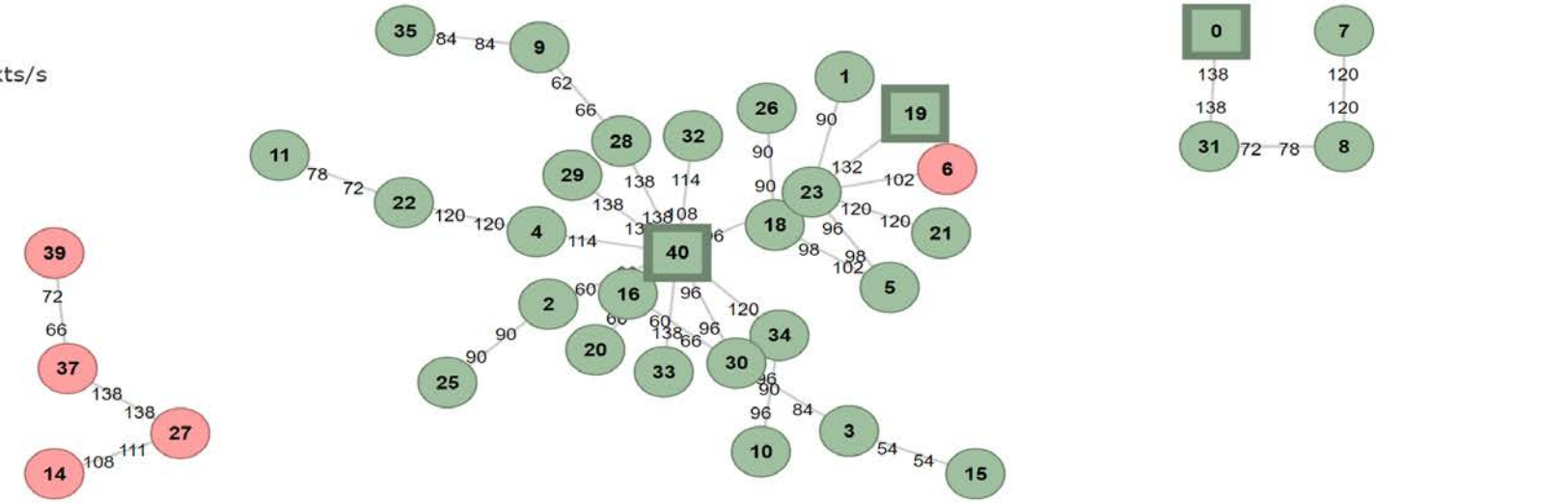
# Dozer

[Burri, von Rickenbach, W]

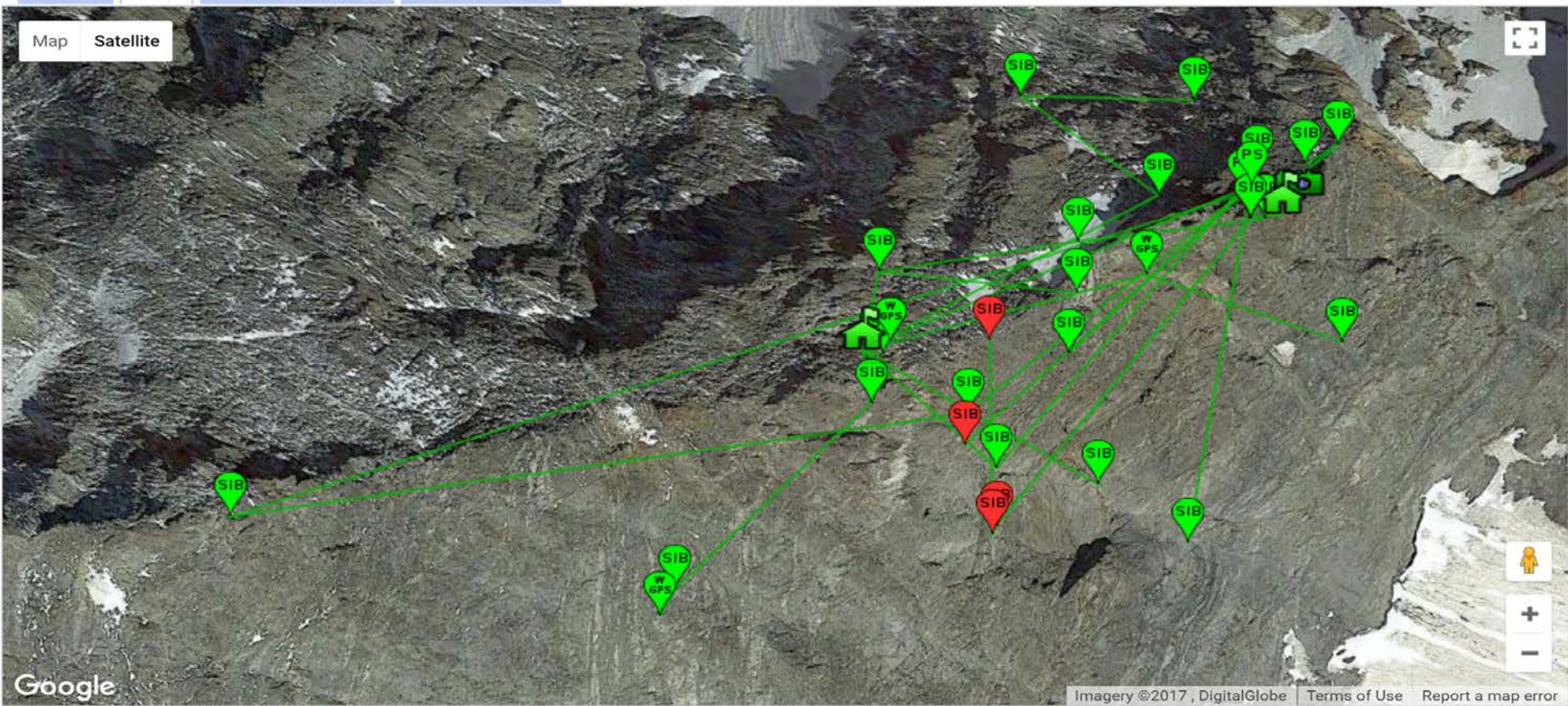
# Energy Efficiency



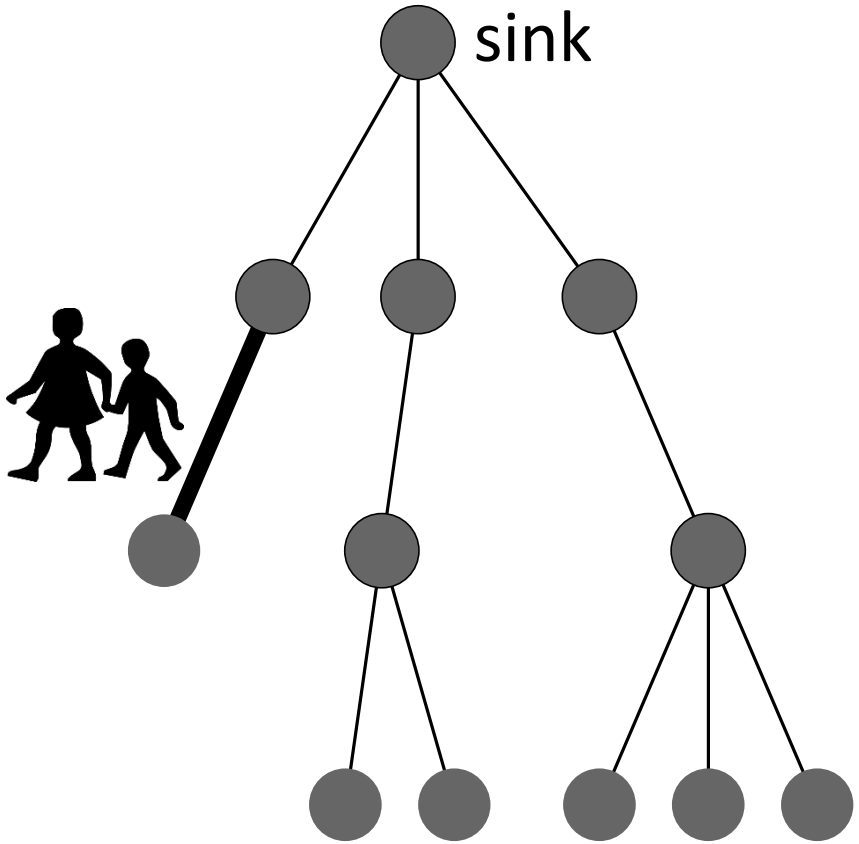
Total: 35
Online: 30
Packetrate: 1.32 Pkts/s




Health | Map | Position Mapping | Configuration



# Energy Efficiency



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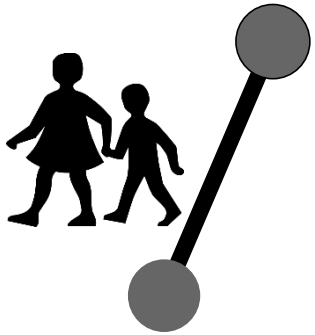
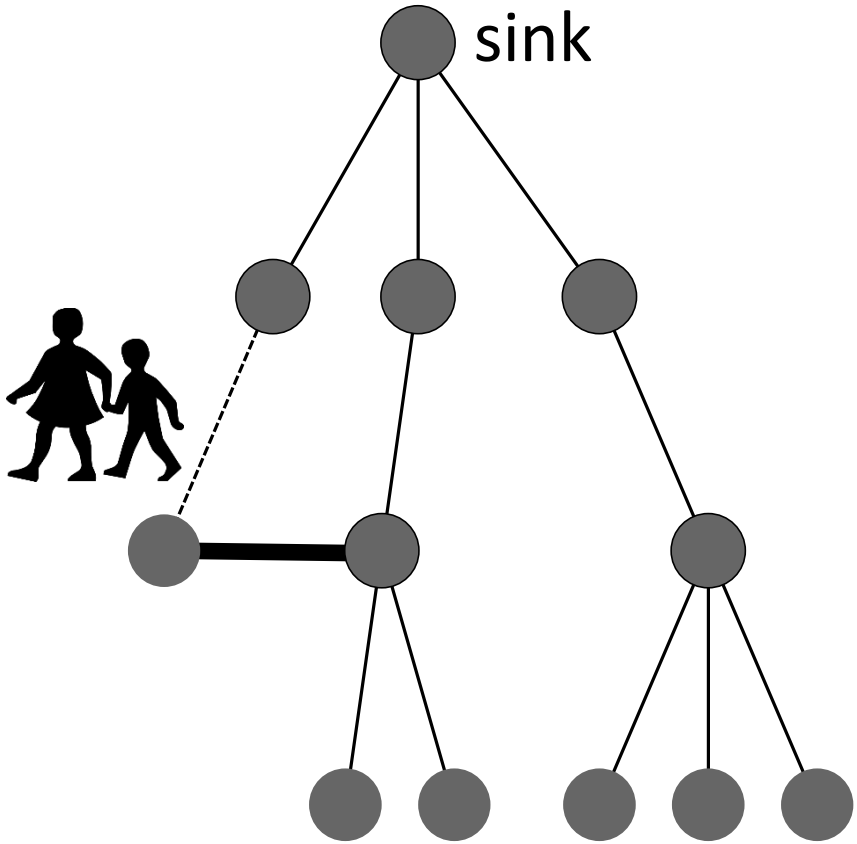
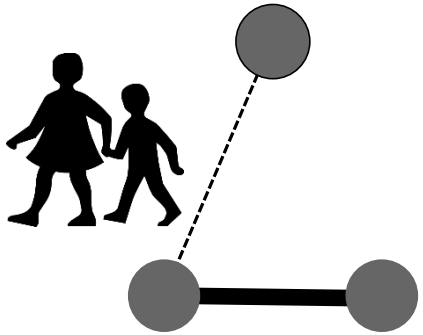


duty cycling, wake up e.g. every 10 seconds
parent synchronizes children
no network wide synchronization
mean energy consumption: 0.066mW, 10y battery

# Reliability



# Reliability



nodes send beacons to reconnect orphans

collisions are explicitly accepted

availability & reliability: 99% to 99.999%


Wireless vehicle detection systems
for outdoor parking lots

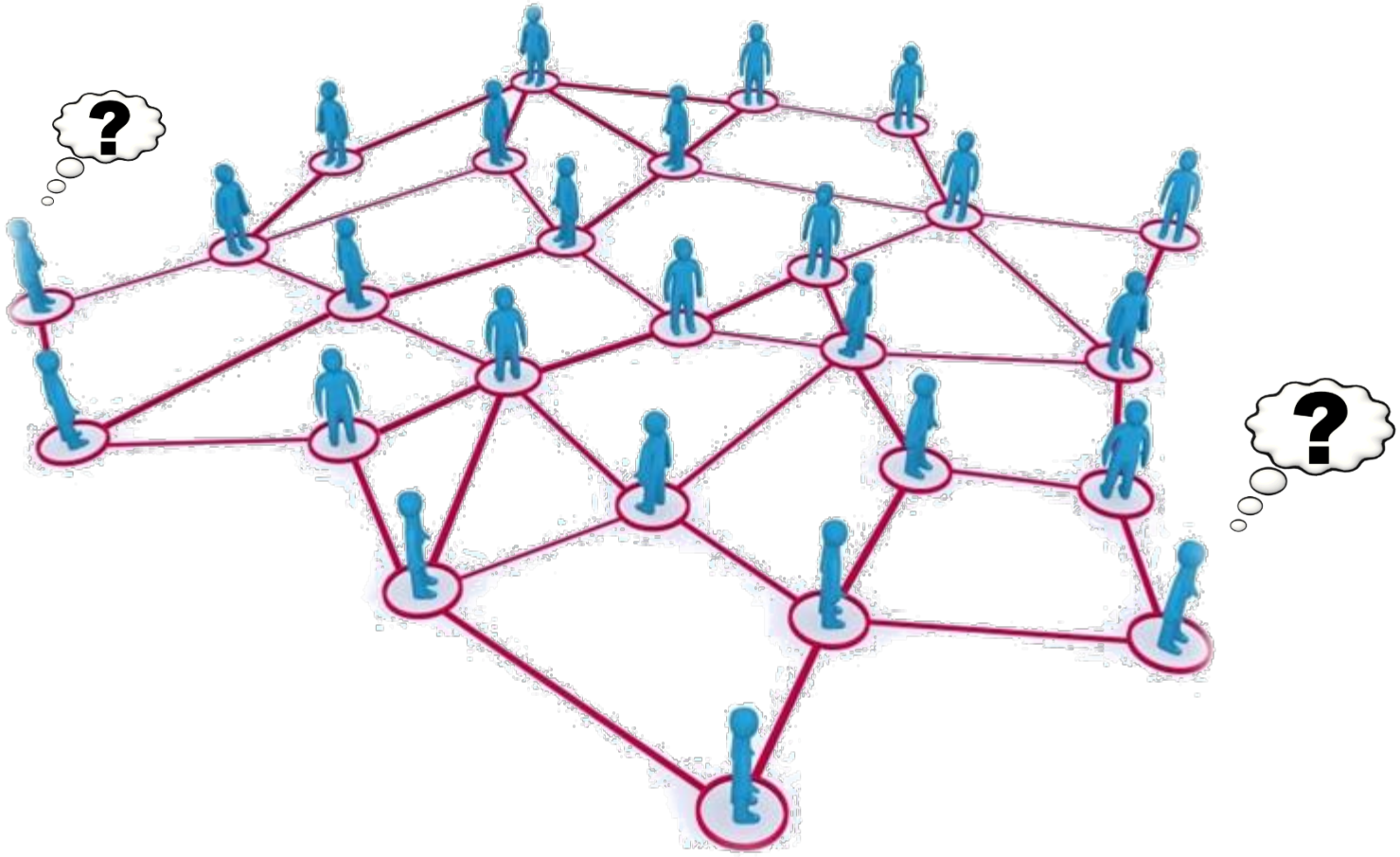
[tinynode]

# Where’s the Theory?

“no network wide synchronization”

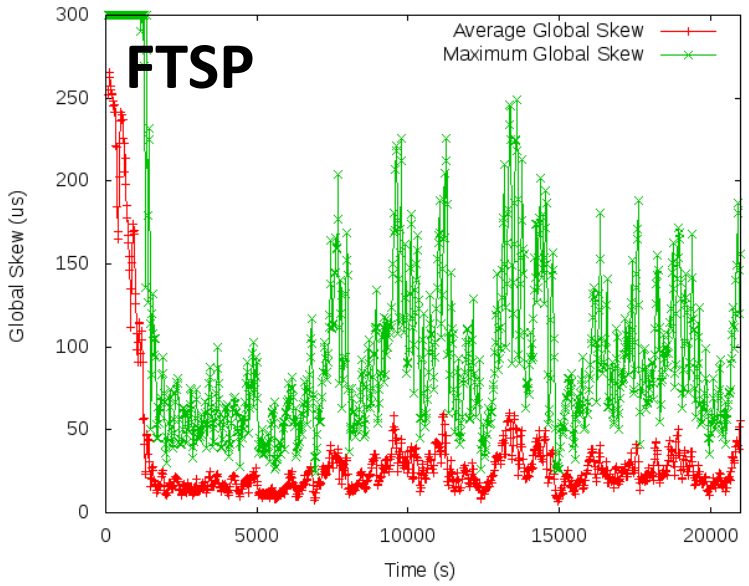
# Network Synchronization is Hard

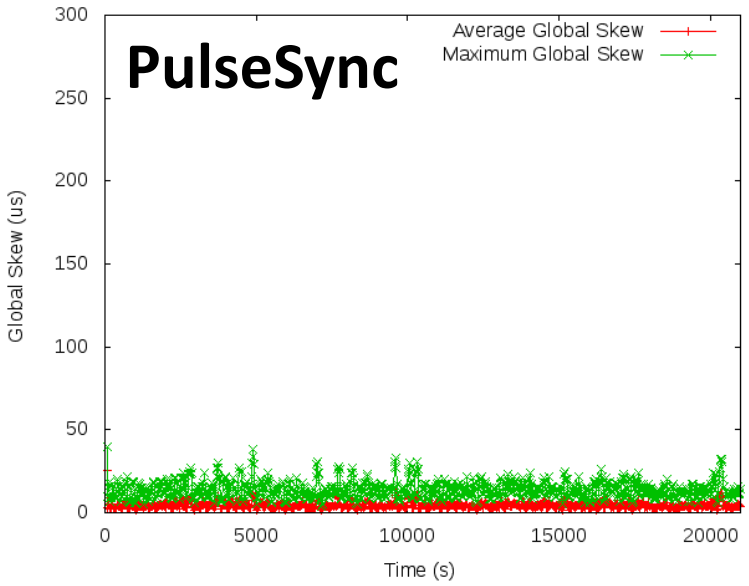
# Network Synchronization



# Tree Based Protocols

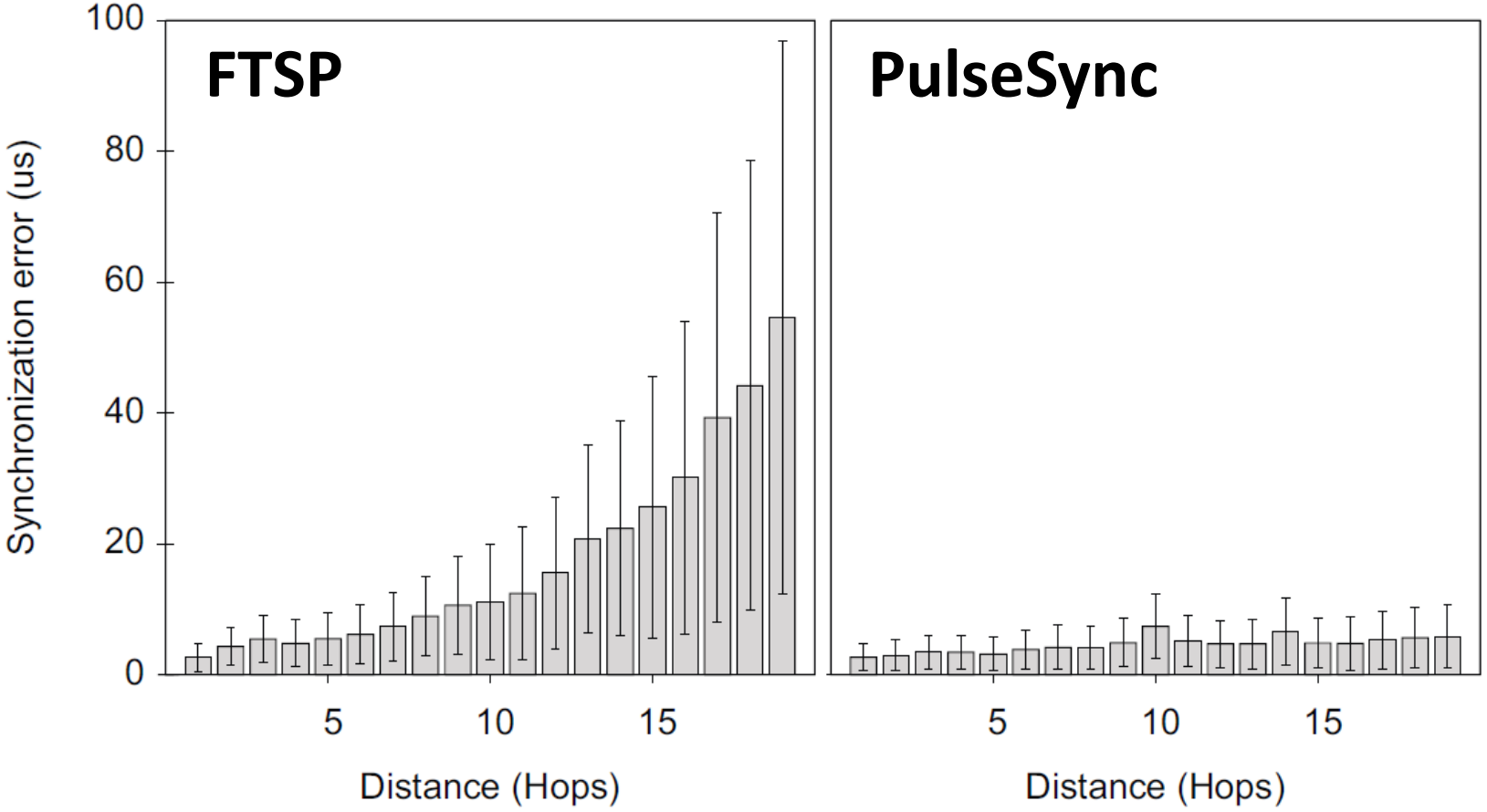
[Lenzen, Sommer, W, TON]



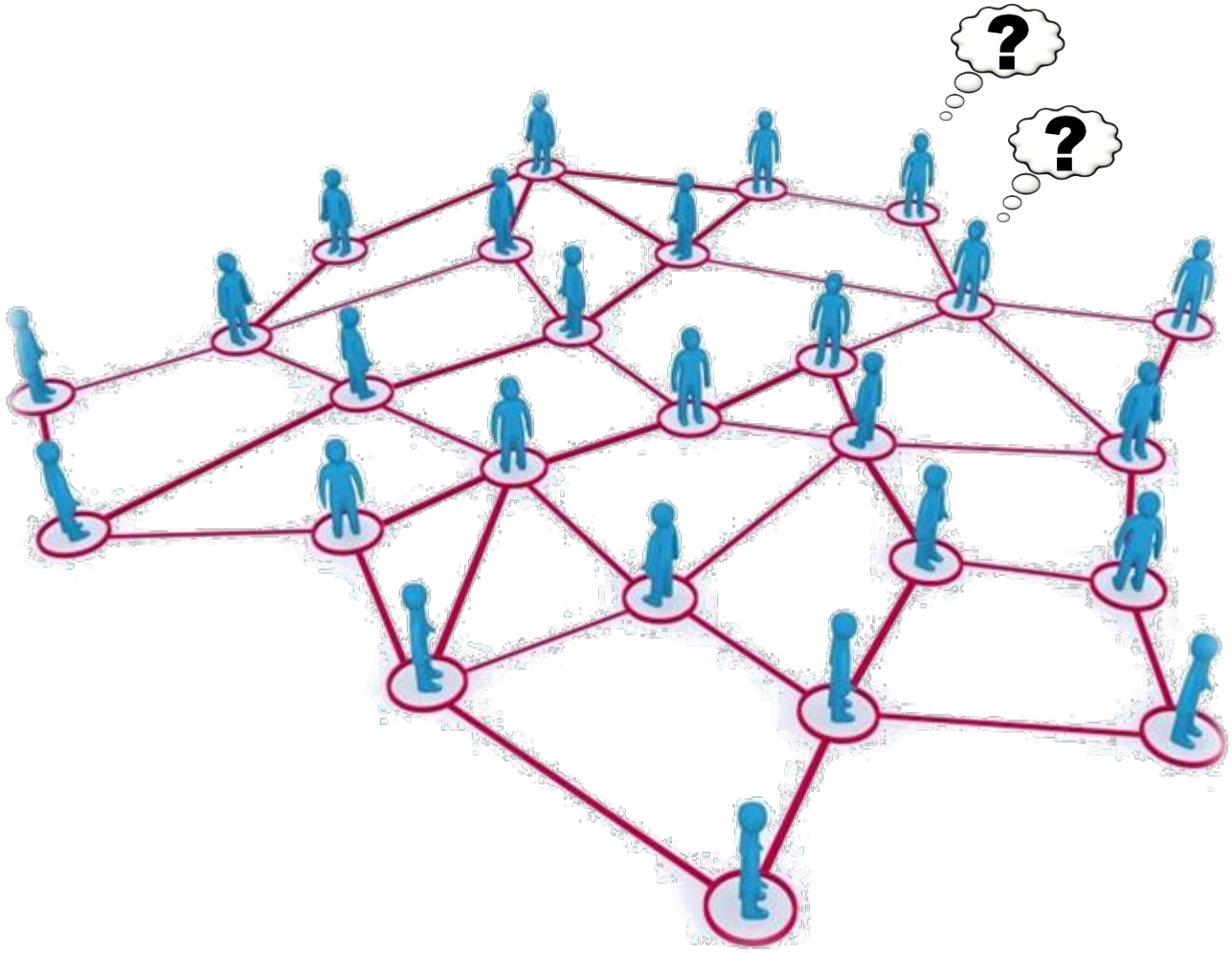




| Synchronization Error | FTSP | PulseSync |
|---|---|---|
| Average (t > 2000s) | 23.96 µs | 4.44 µs |
| Maximum (t > 2000s) | 249 µs | 38 µs |

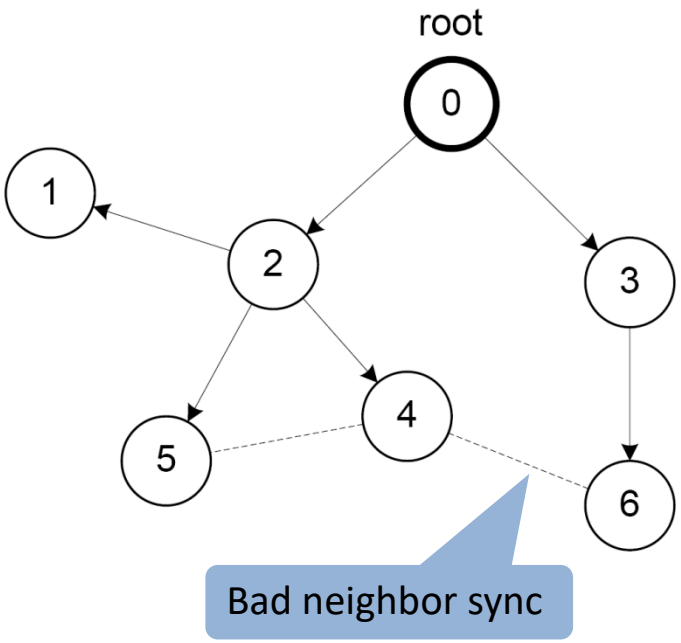
# Error with Distance



# Neighbor Synchronization

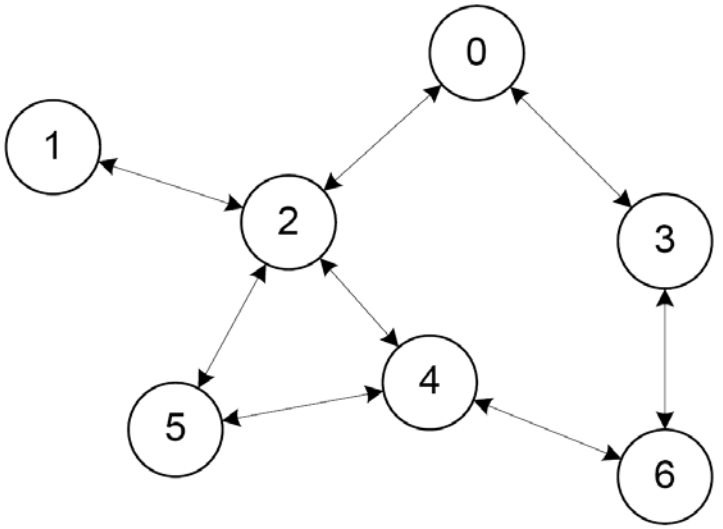


# Neighbor Synchronization?




Tree-based Algorithms

e.g. FTSP

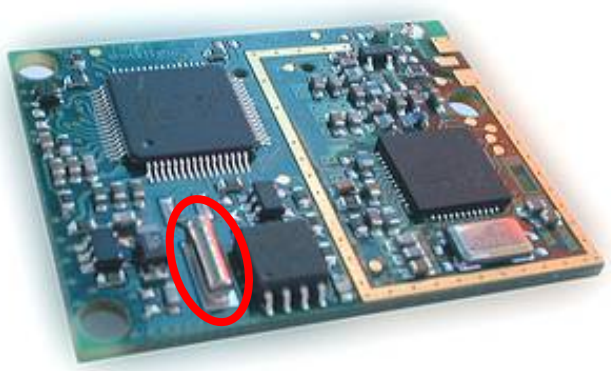


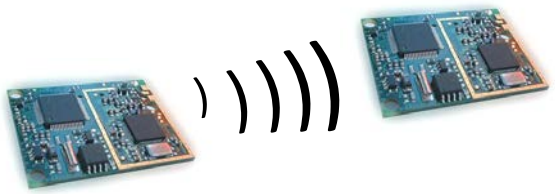

Neighborhood Algorithms

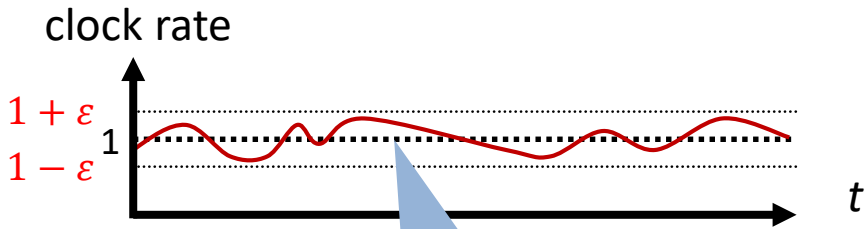
e.g. GTSP

# Theorem:
# Neighbor Sync is Somewhat Hard

# Model: Drift & Jitter

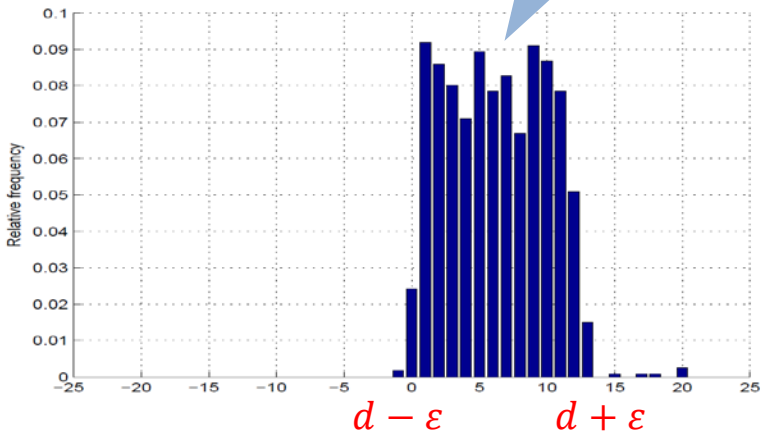







bounded errors (worst-case)

message delay



# Reasonable Time Must Behave!

no stopping

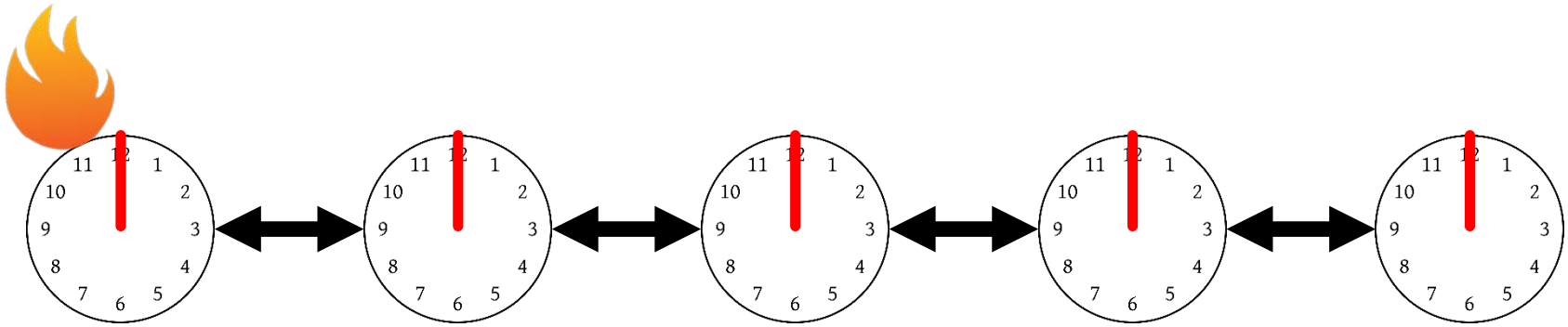
no jumping

# Example: Neighbor Sync is Hard

sync to fastest neighbor

message delay = 1

$d + \varepsilon$



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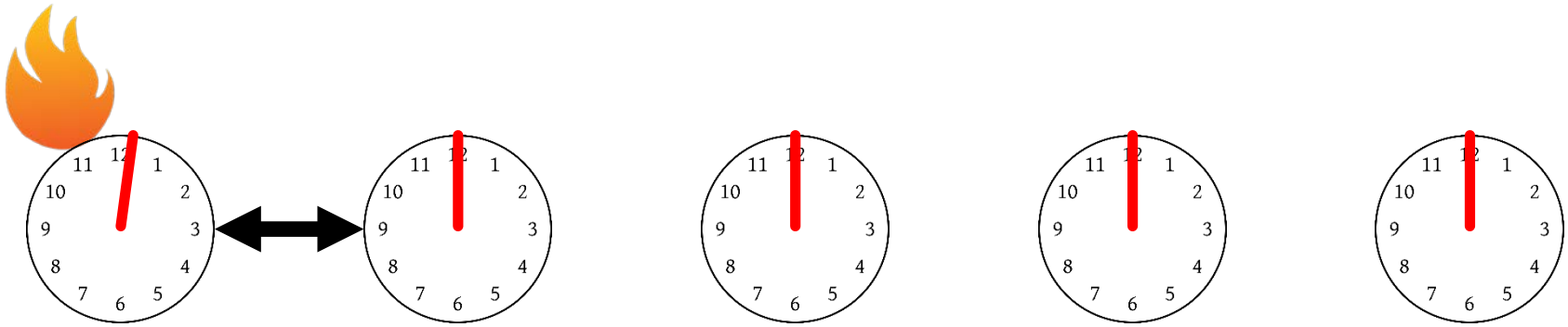

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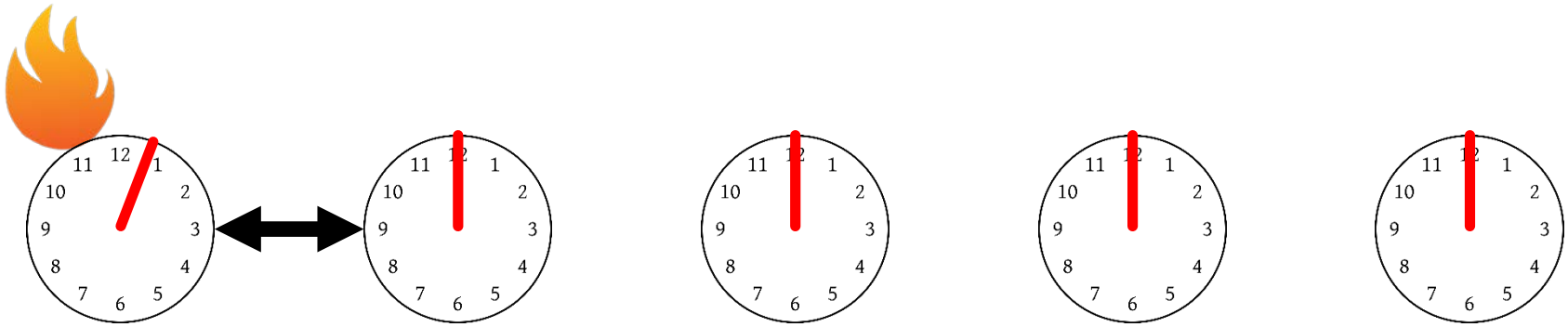

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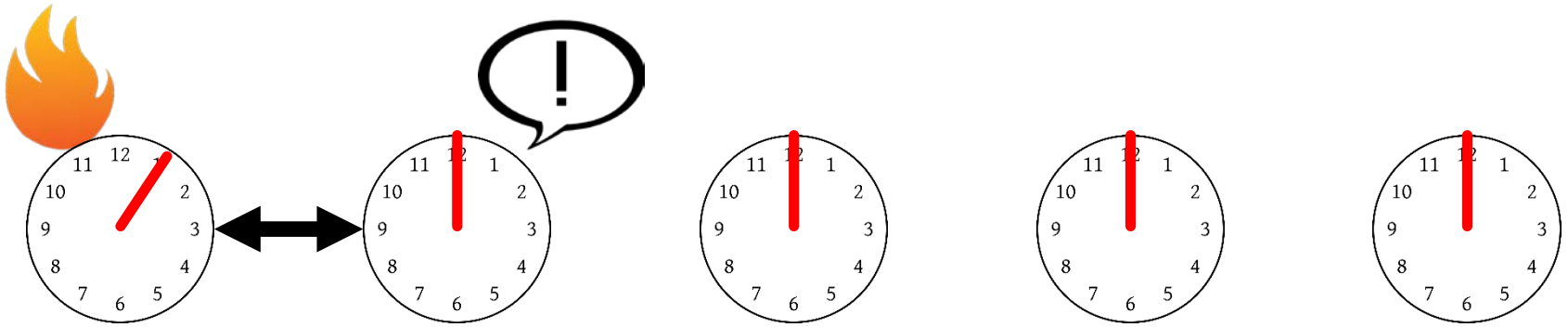

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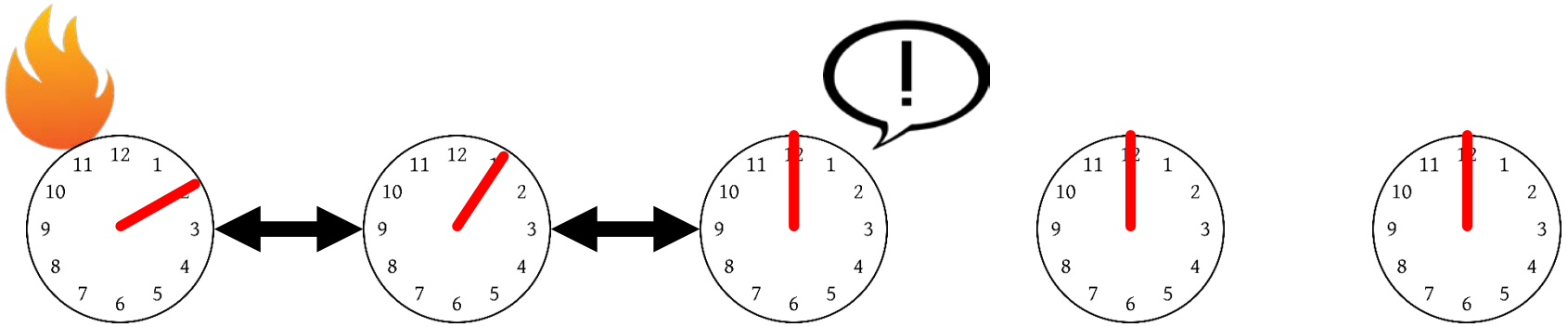

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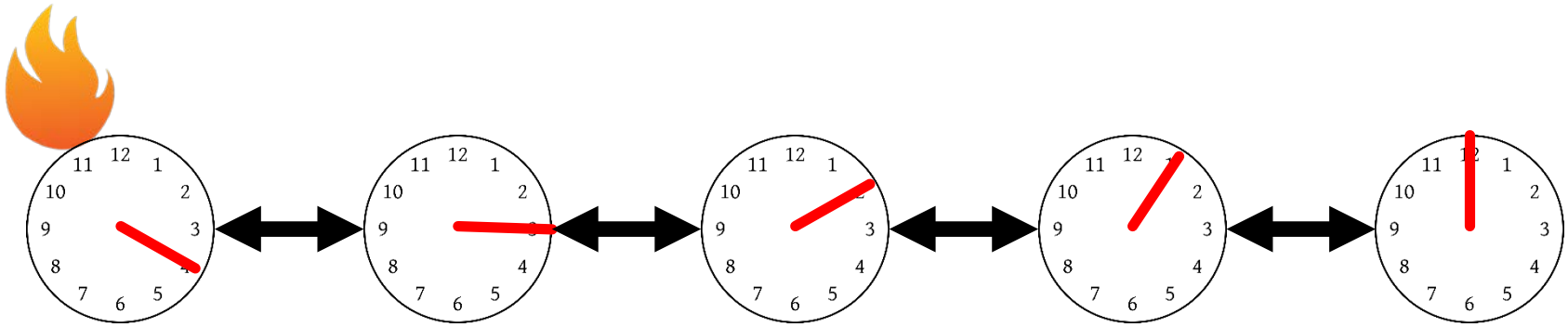
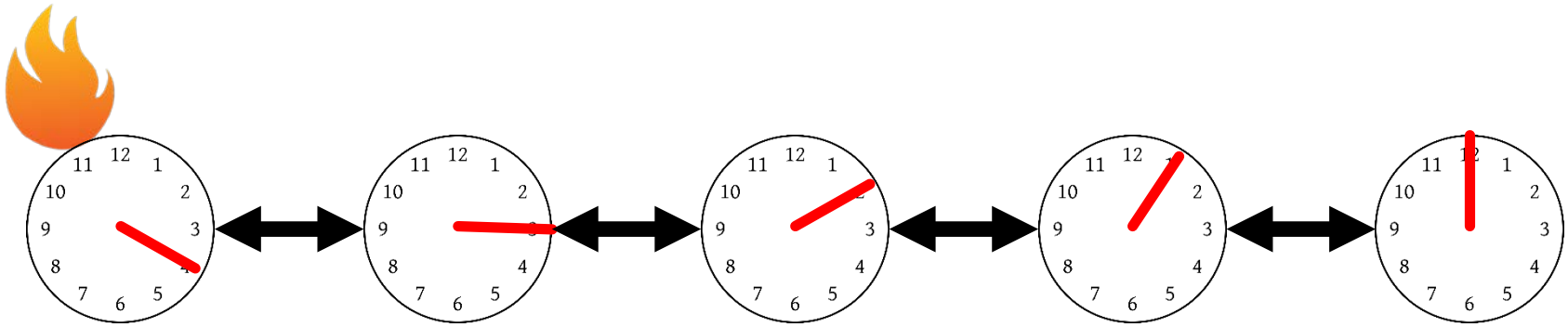


# Example: Neighbor Sync is Hard

sync to fastest neighbor

message delay = ~~1~~ 0

$d - \varepsilon$



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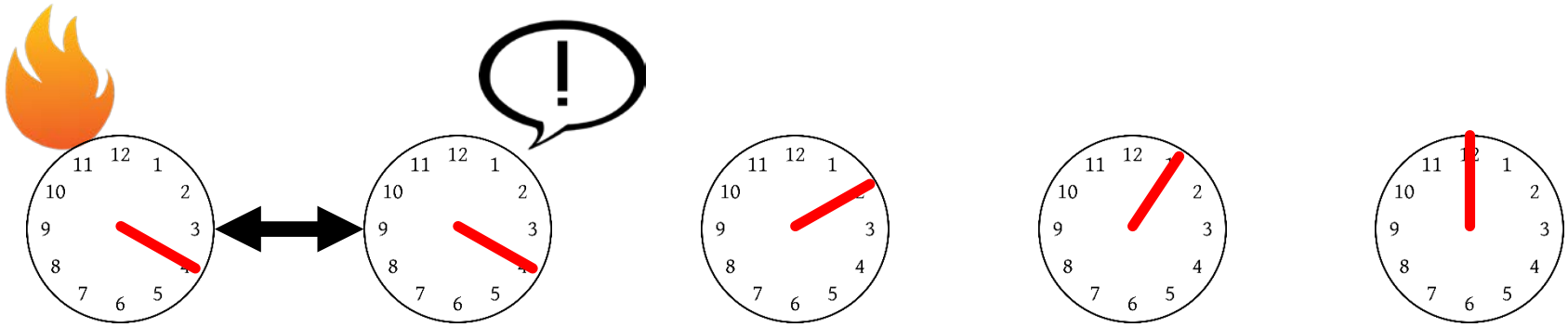

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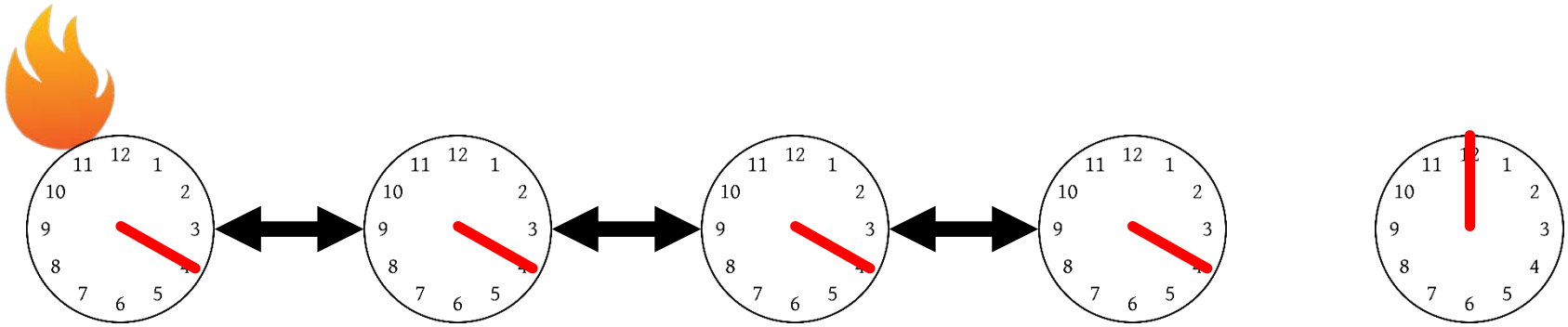

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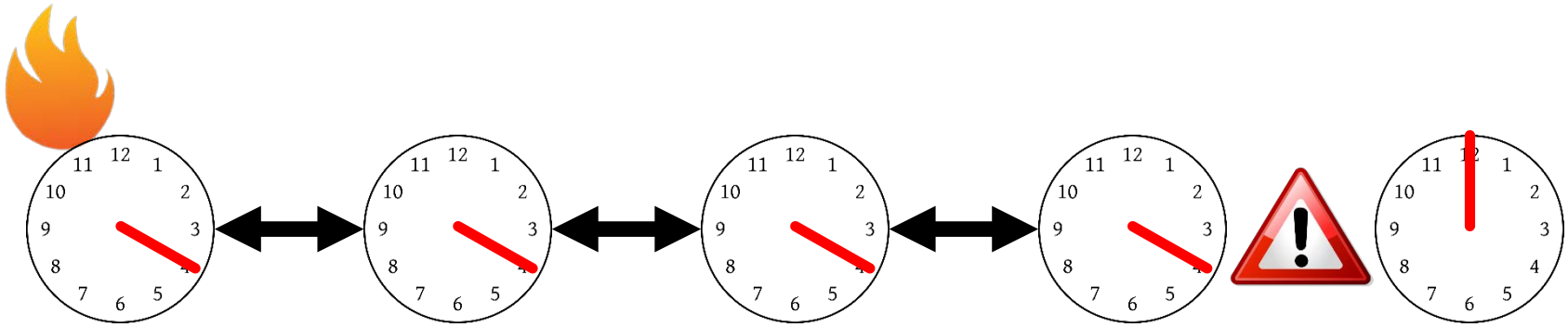
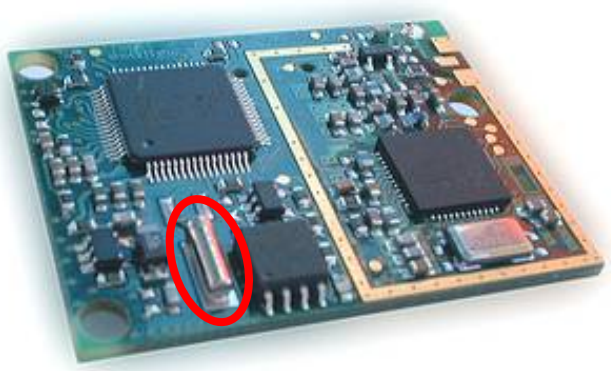


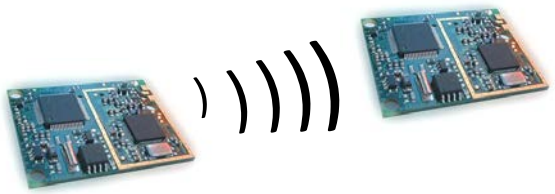
# Sync To Fastest Neighbor: Local Skew Can Be Diameter

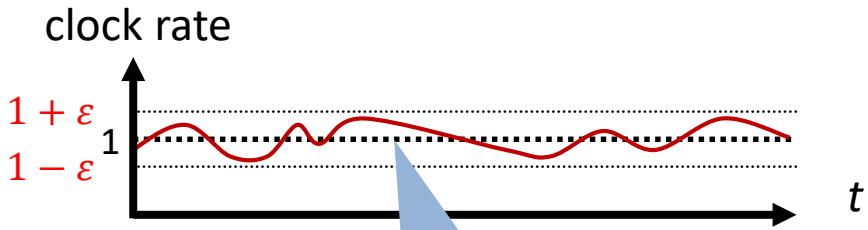
# Average of Neighbors:
# Local Skew Can Be Diameter Squared

# Better Protocol?

# Reminder: Drift & Jitter

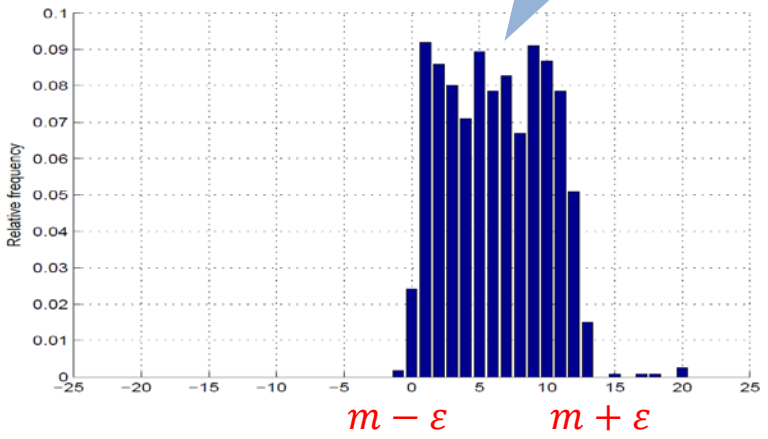







bounded errors (worst-case)

message delay



# Theorem:
# Neighbor Sync is Somewhat Hard

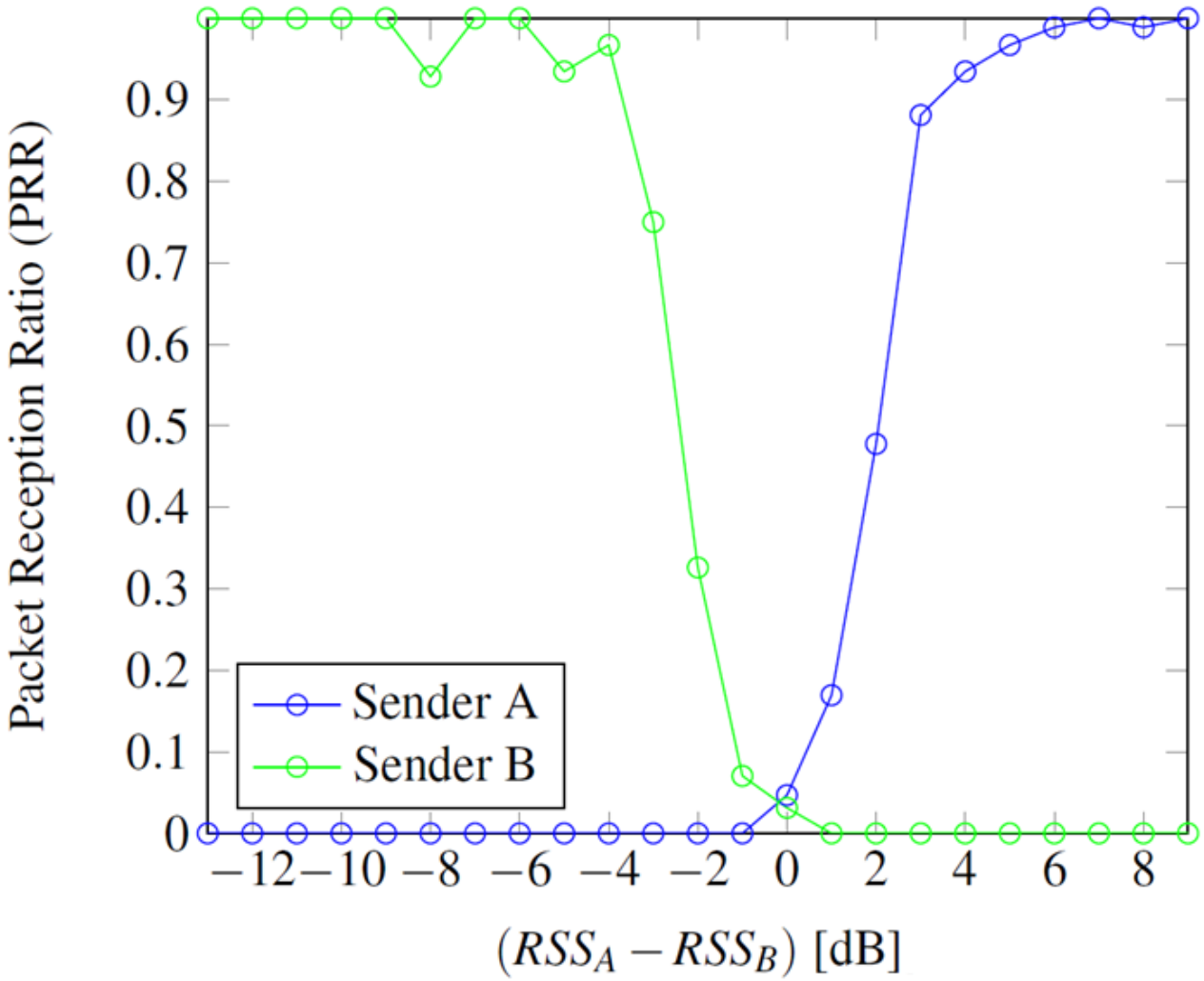
neighbor sync error = log diameter
lower bound: difficult proof
matching upper bound: not trivial as well

[Lenzen, Locher, W, JACM]

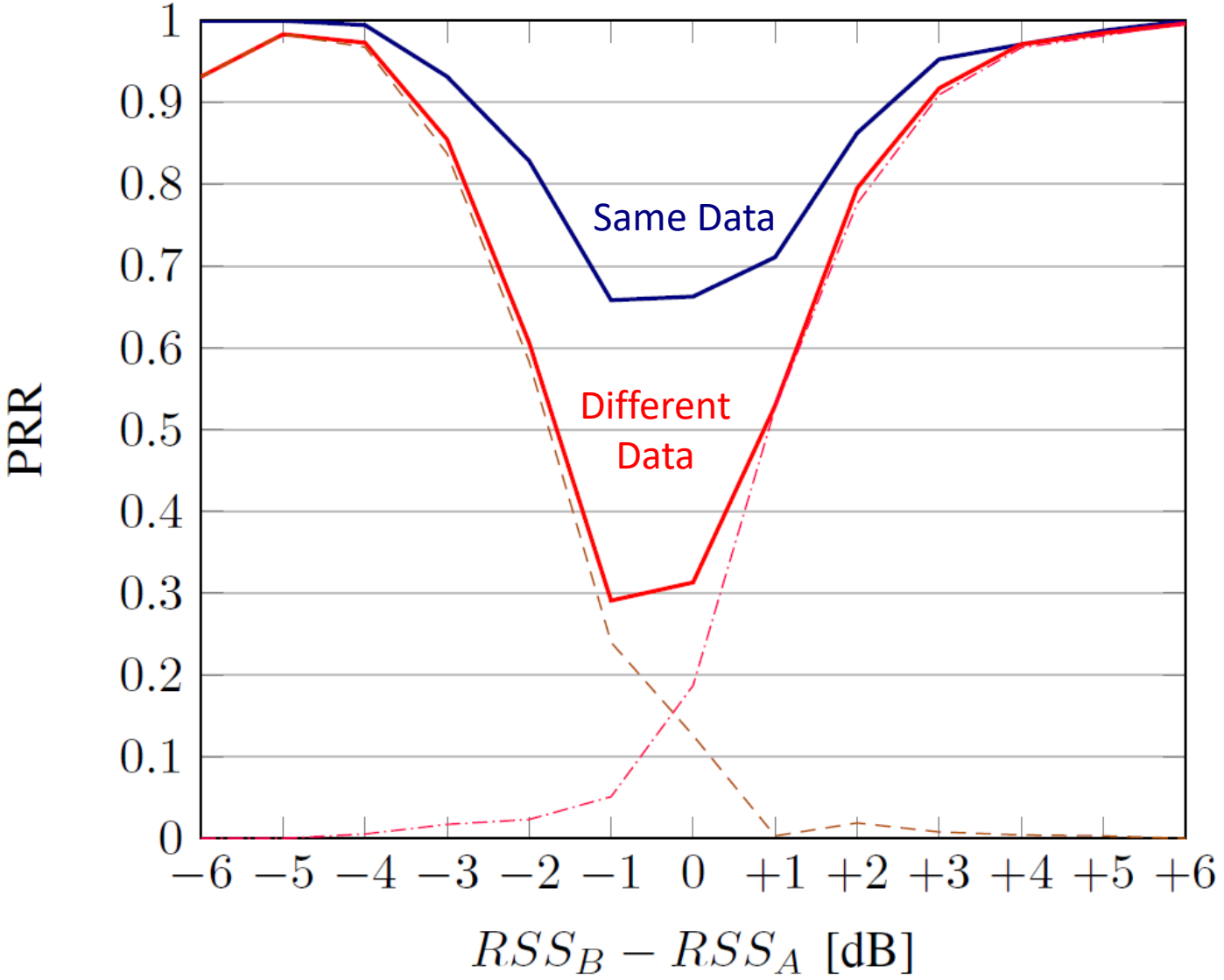
# *Speaking of Synchronization*

*Roger Wattenhofer*

# The Capture Effect



# Constructive Interference



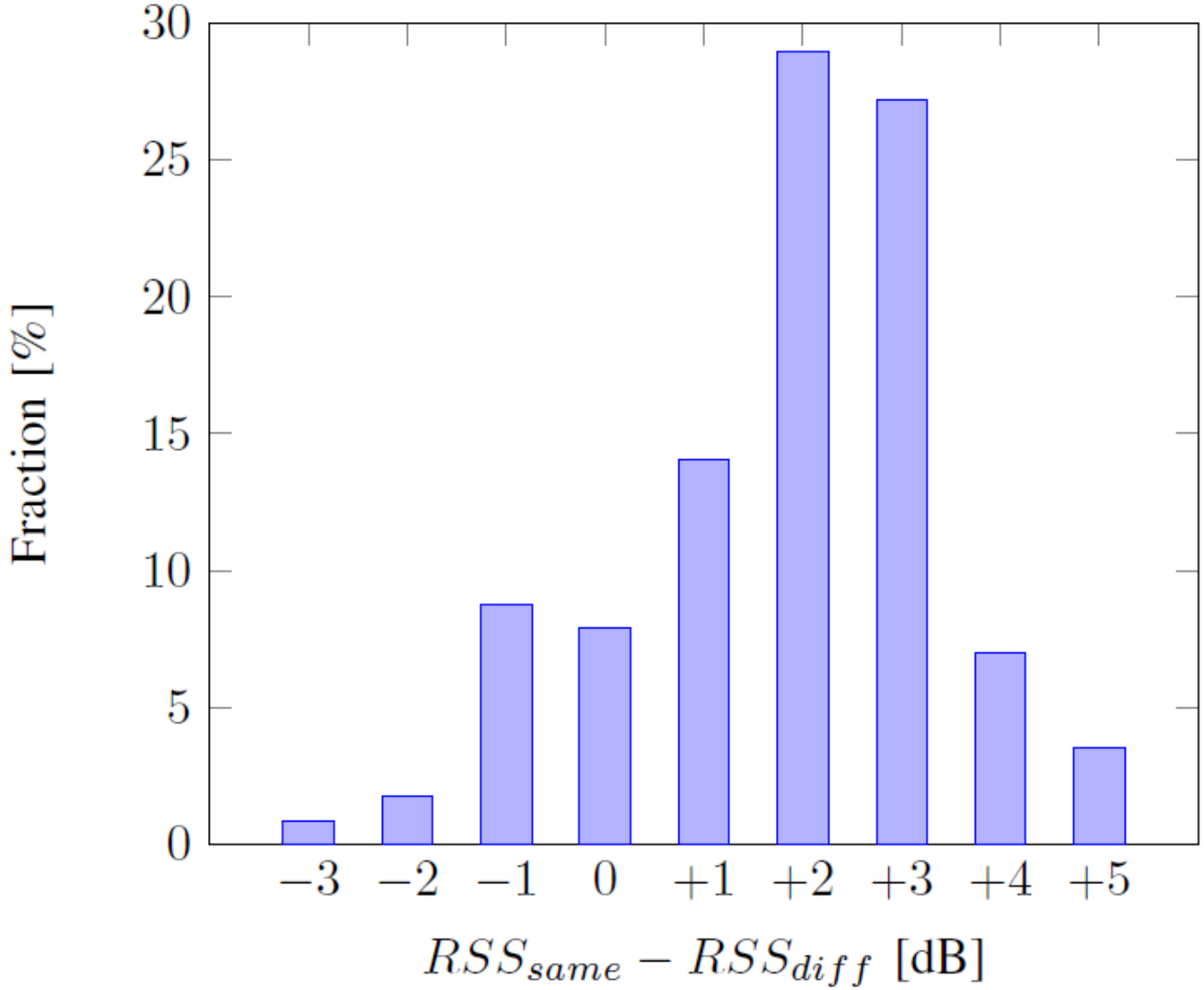

[König, W]

# Accurate Synchronization

neighbor sync error: 0 … 0.25 µs
transmission timing: 0 … 0.25 µs

[König, W]

# RSS Gain



Or…

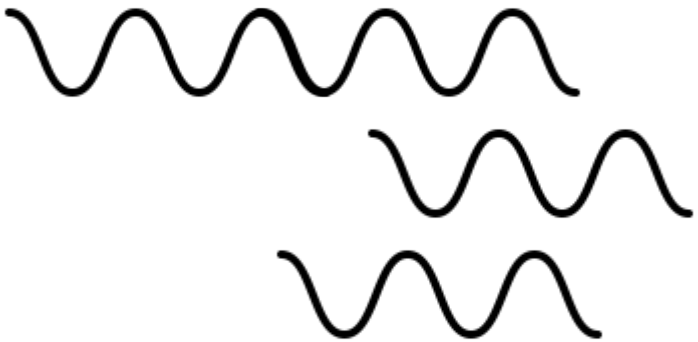

[König, W]


[König, W]

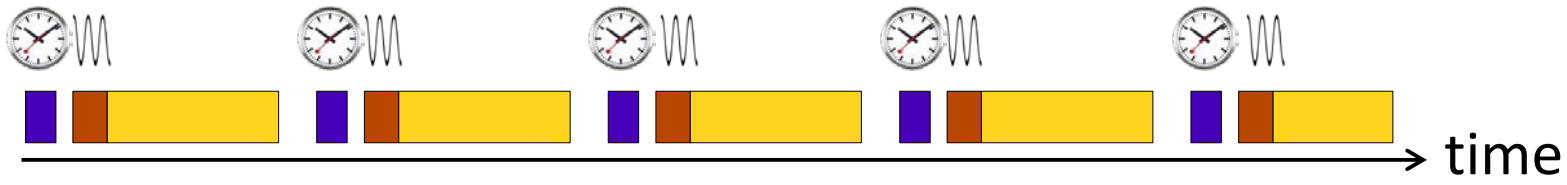
# *Playing With Radios: Alarming*

*Roger Wattenhofer*

# Just Send Waves



# Slotos




[Flury, W, IPSN]

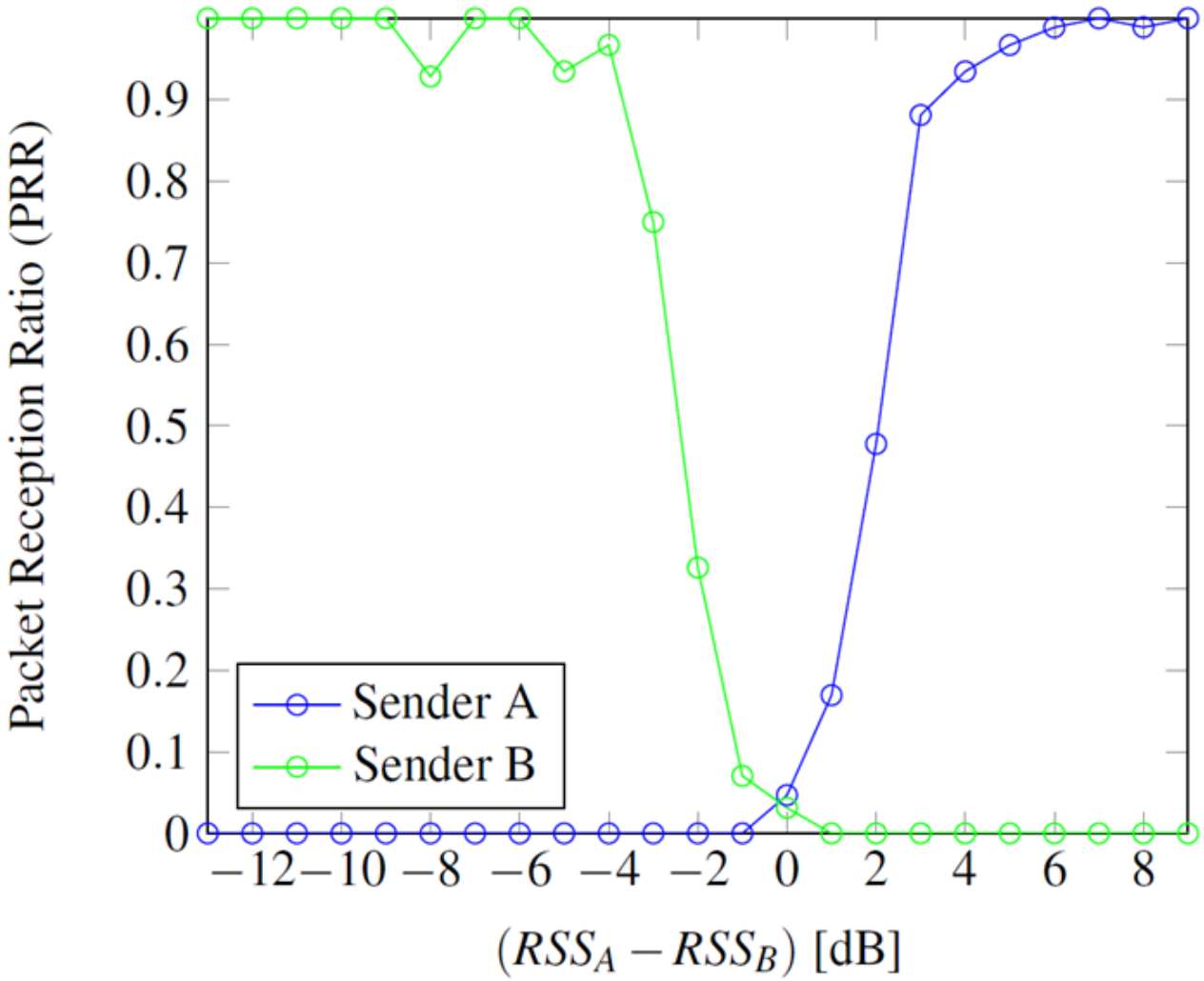
# Surprisingly Reliable

False Positives: 0.8%
False Negatives: 0.08%

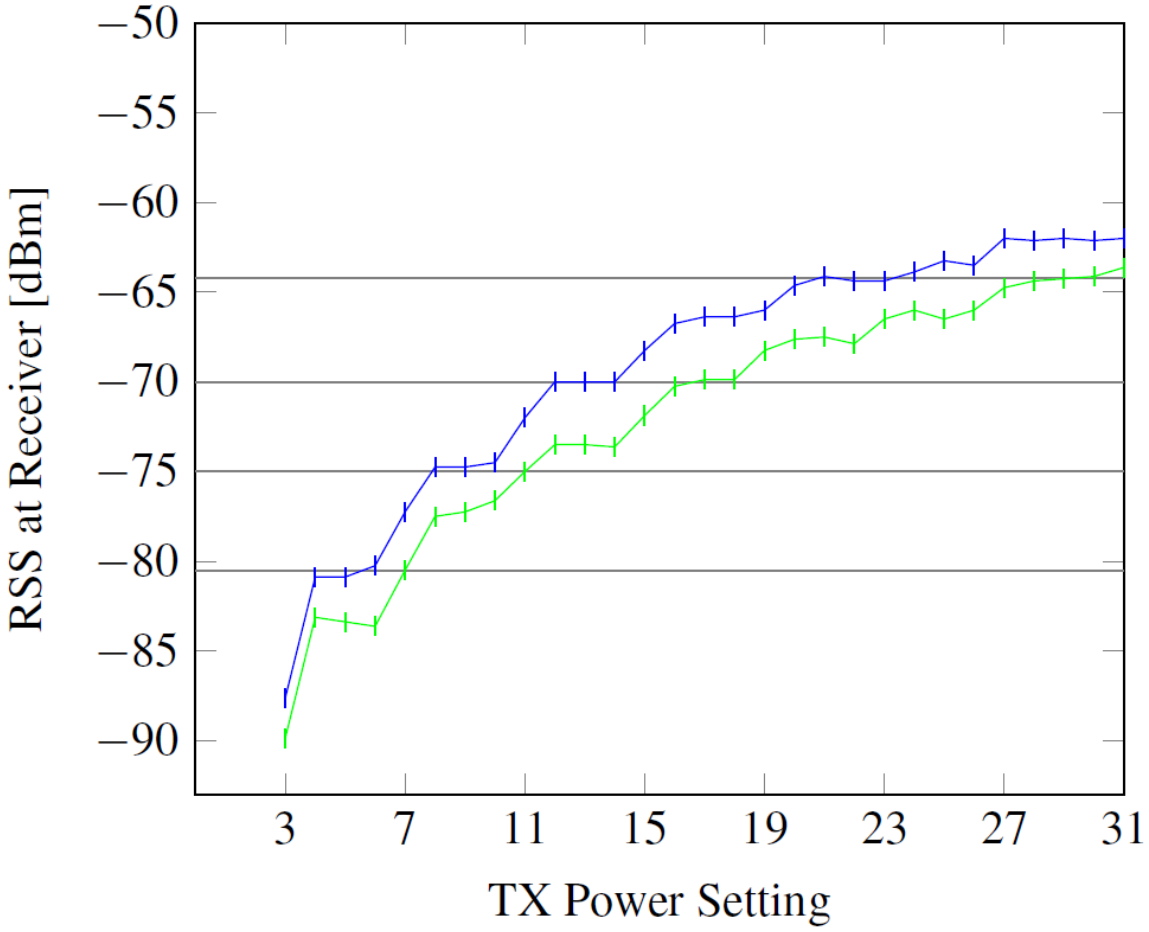
# Alarming with Packets?


[König, W]

# The Capture Effect



# Protocol Layering



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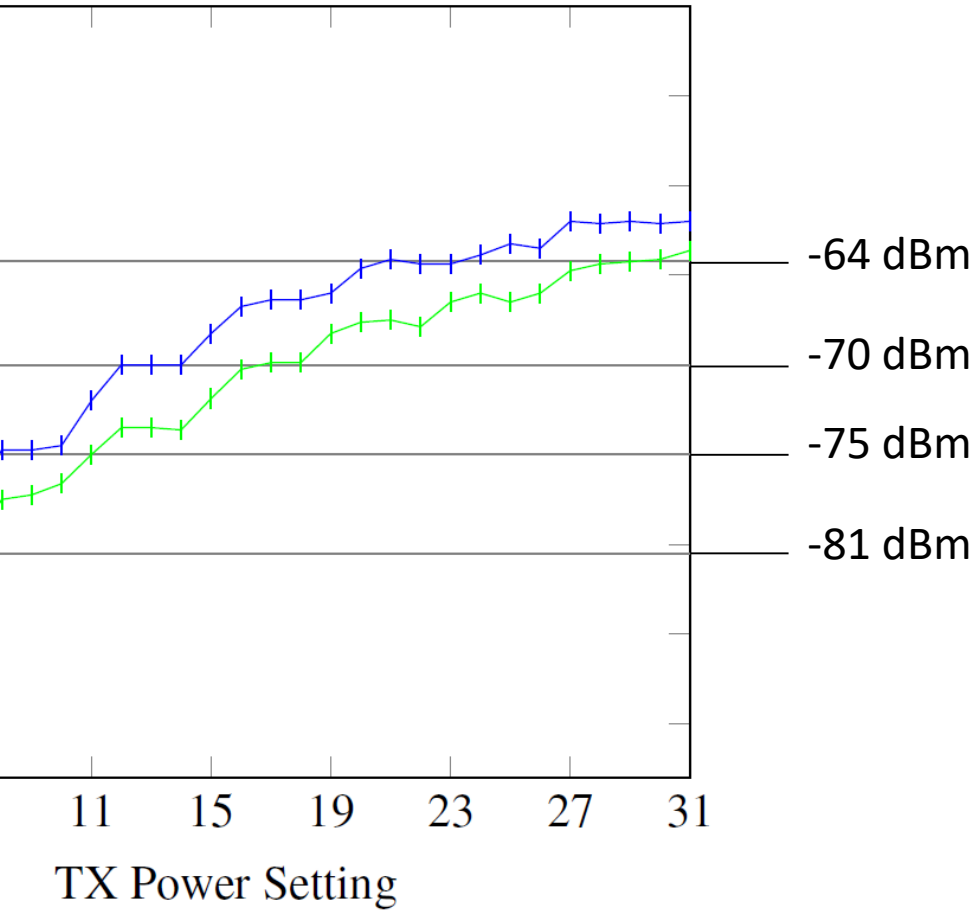
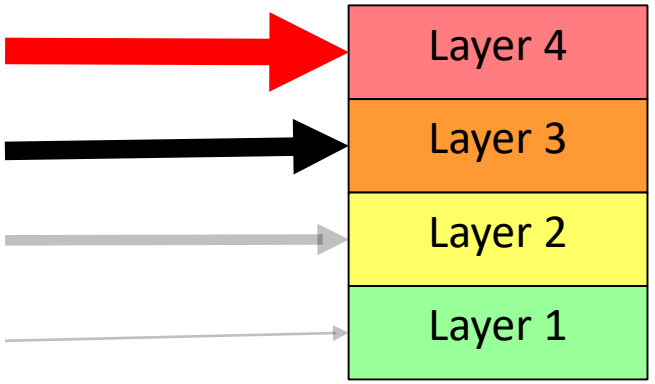
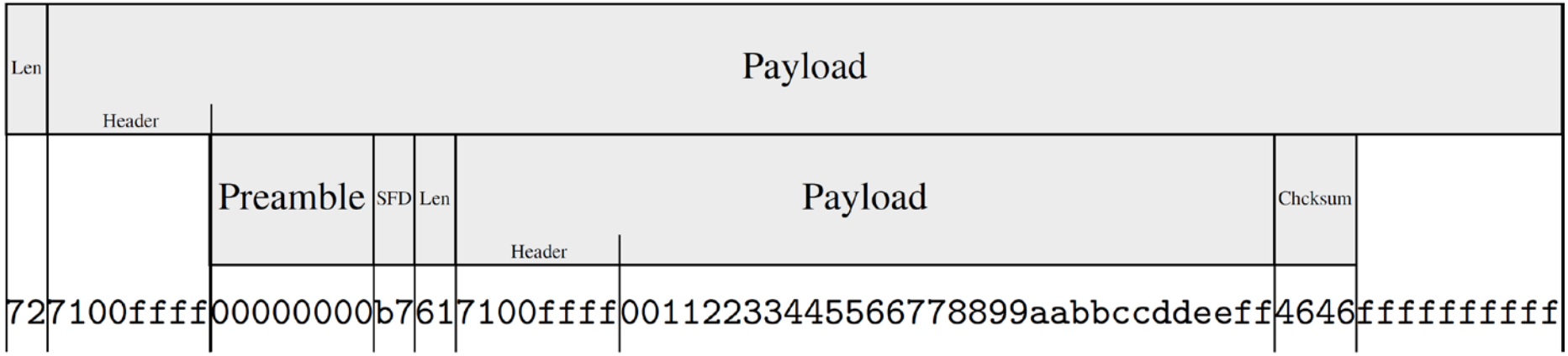



[König, W]

# Packet in Packet



# Naïve Injecting

```
727100ffff22222222d10313229999223345566770011aabbccddeeff889960600ff3ffcfcf
727100ffff11111111c0720211888811223345566770099aabbccddeeff885757ffffffffff
727100fffff77777777a6506077eeee7700112233445566ff8899aabbccddee3535fffffffff
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727100ffff11111111c0720211888811223345566770099aabbccddeeff885757ffffffffff
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```

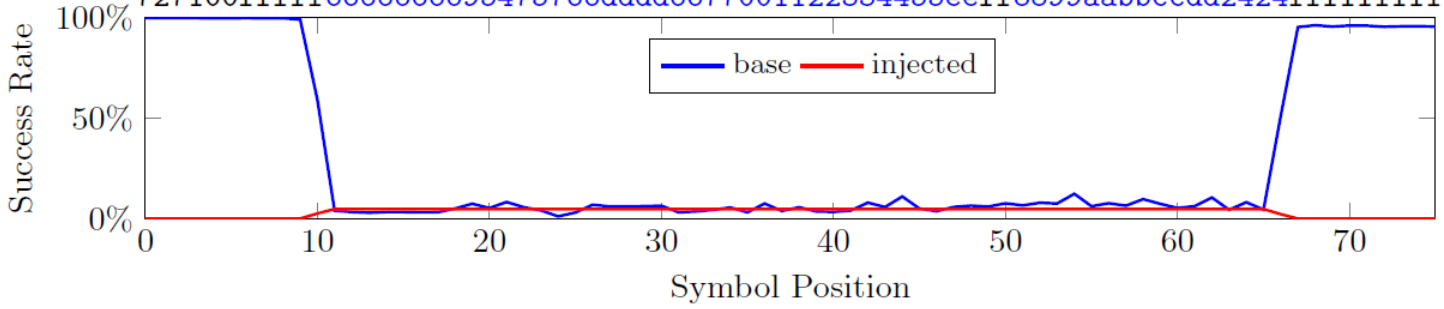

# After Clock Sync

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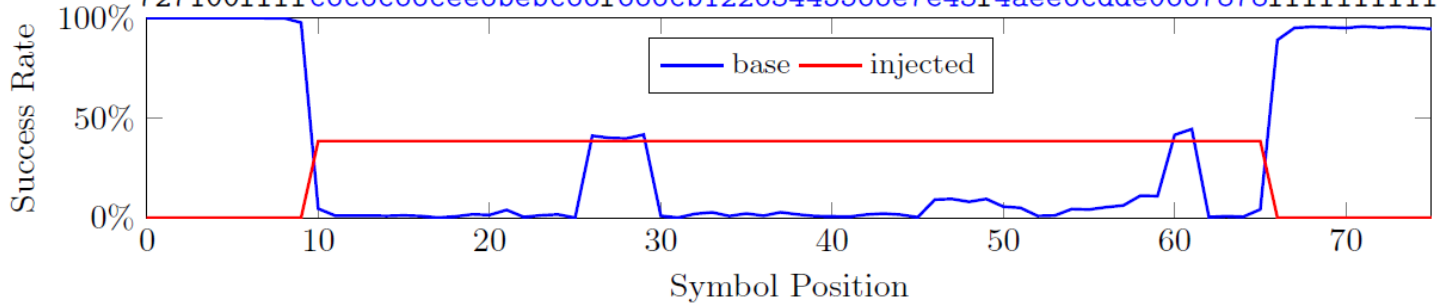

# Symbols Descrambled

727100ffff00000000b7617100ffff00112233445566778899aabbccddeeff4646ffffffffff
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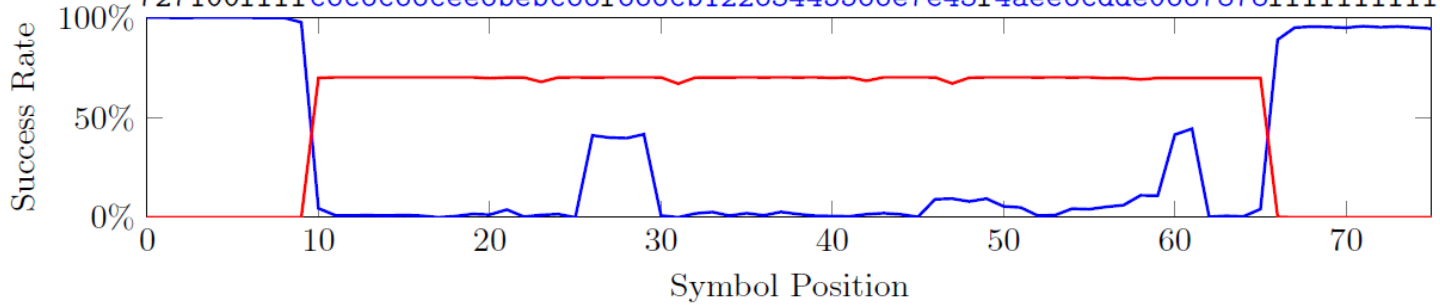
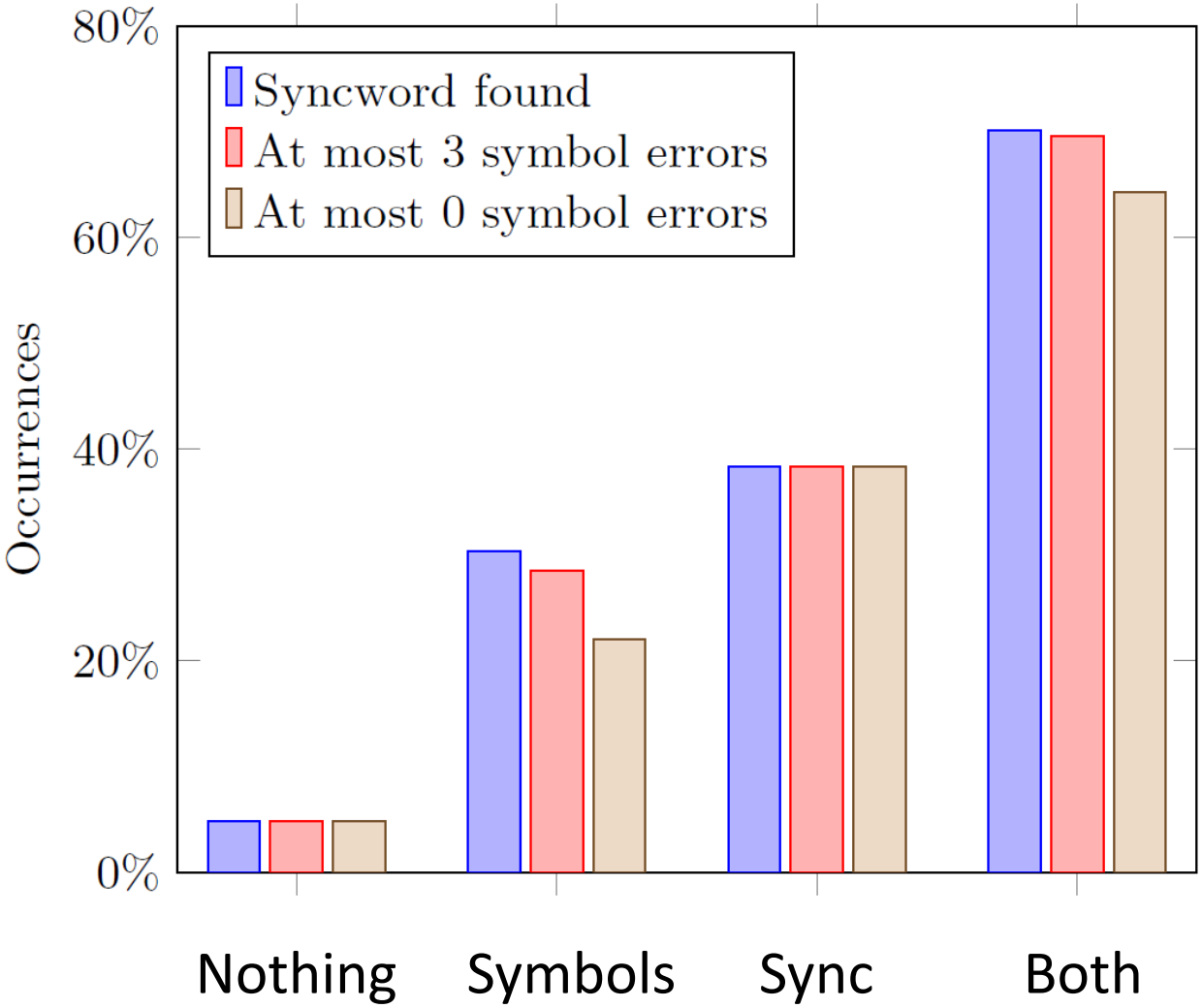


# Measurements



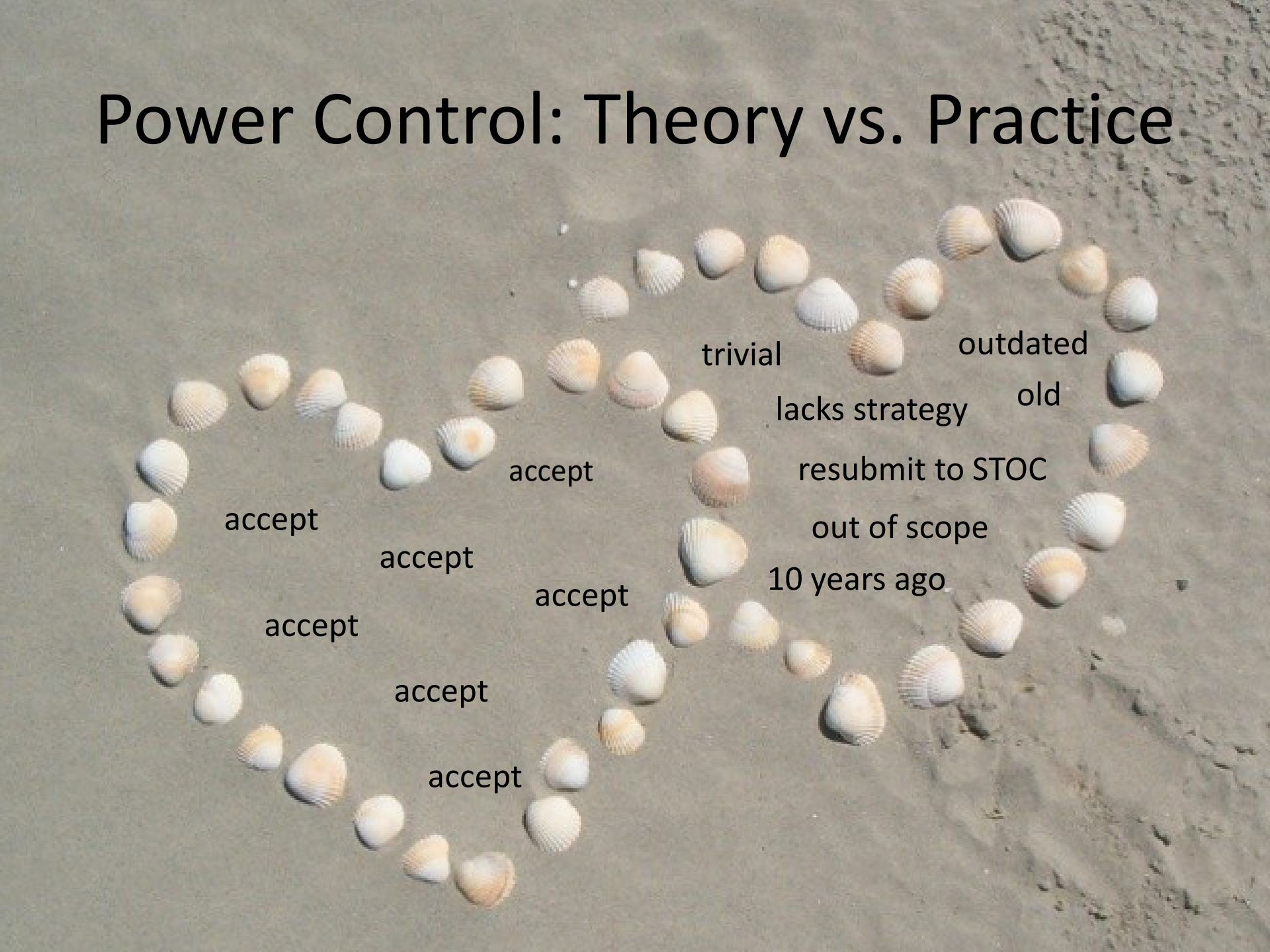

[König, W]

# *Speaking of Power Control*

*Roger Wattenhofer*

# Offending the Audience

# Power Control: Theory vs. Practice



# Power control is old

e.g. LTE

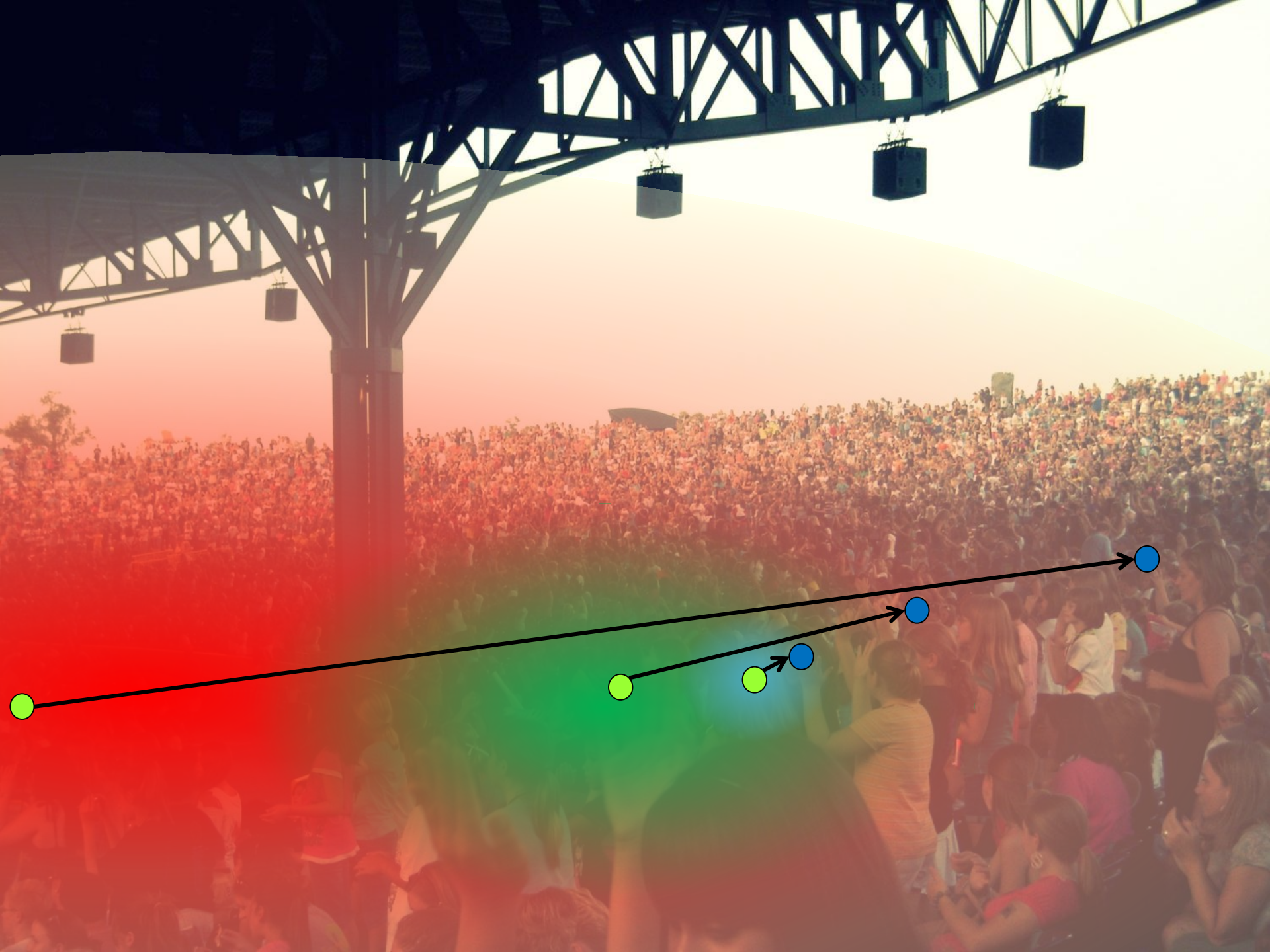
… but …

Lots of theory progress how to schedule & power wireless transmissions in a network

[Moscibroda, W]
[Goussevskaia, Halldórsson, W]
[Kesselheim]

# Many Variants and Extensions

models on top of SINR
robustness results
different approximation criteria
distributed algorithms
etc.



# Is the Theory Practical?

about 30% more throughput
more reliable communication links

(but still too much overhead)

# “Dutch Propositions”

# Proposition

In sensor systems, theory ≠ practice.*

*There are exceptions. Unfortunately, practical research does not seem to believe that these exceptions exist.

# Sensor Network Theory

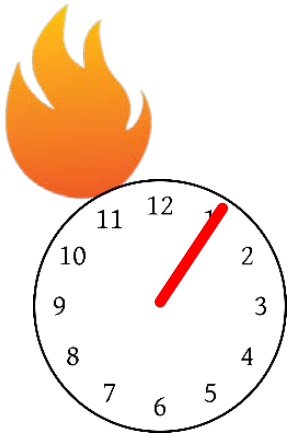
How many lines of pseudo code

Can you implement on a sensor node?

My advice: invest your research £££s

in ... impossibility results and lower bounds!

# Summary





Professor Position @ ETH Zurich
Embedded Information Systems