# High-Speed WPAN MAC Performance Evaluation and Enhancement


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# Session Agenda

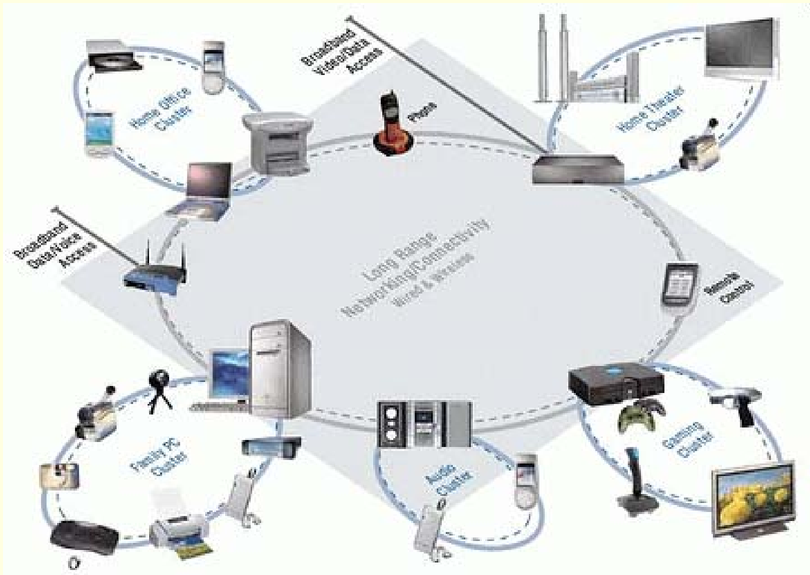
- Preamble
  - MAC Sub-Layer Protocols
  - Superframe Structure
  - PCA Channel Operation
- Simple System Model
- Advanced System Model
- Performance Optimization
- Noisy Channel Performance
- Standard Enhancement
- Summary and Publications

# High-Speed WPAN Background

## History

- UWB PHY:
  WiMedia Alliance – MB-OFDM
  (Intel) **vs.**
  UWB Forum – DS-UWB
  (Freescale)
- IEEE 802.15.3a task group (TG3a) suspension
- MB-OFDM ECMA-368 and
  ISO/IEC 26907 standardization

## Application

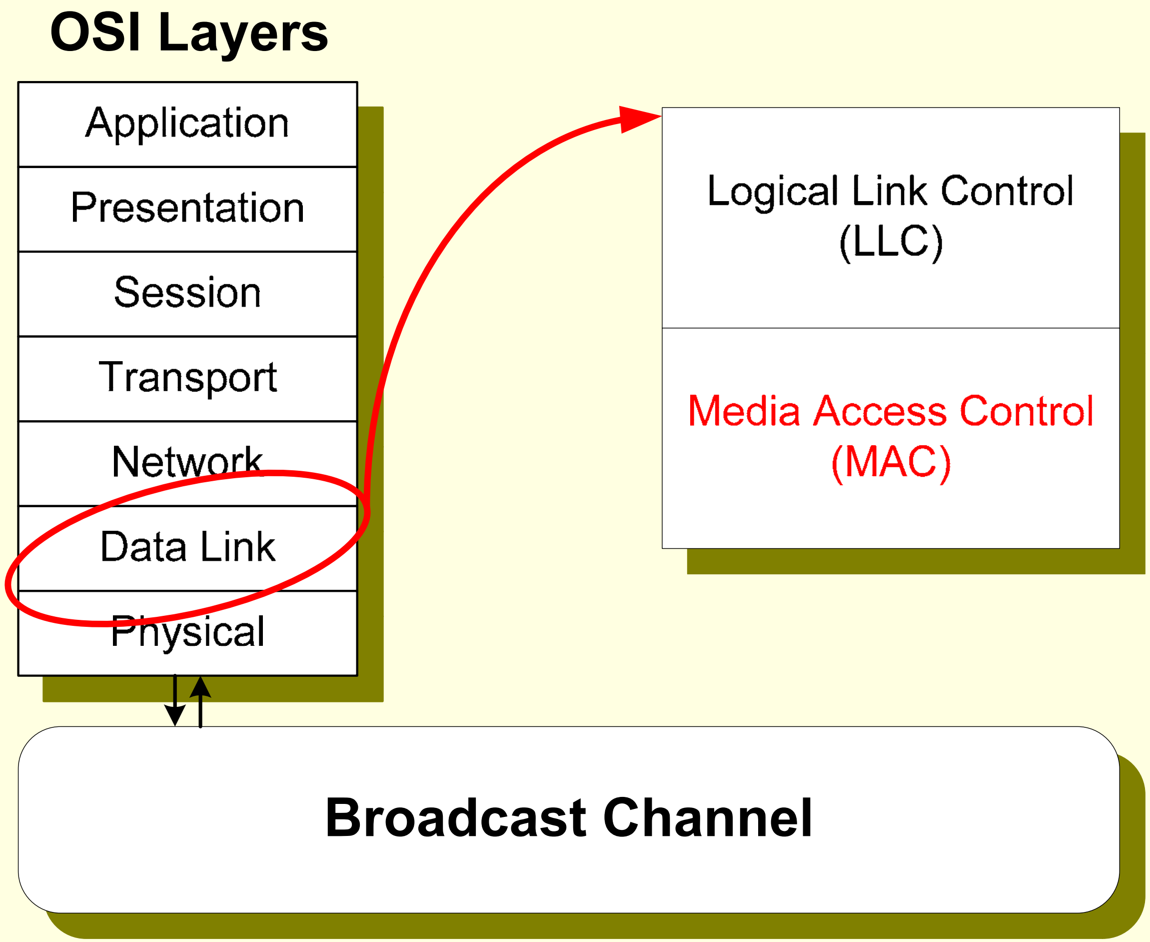



*http://www.ixbt.com/*

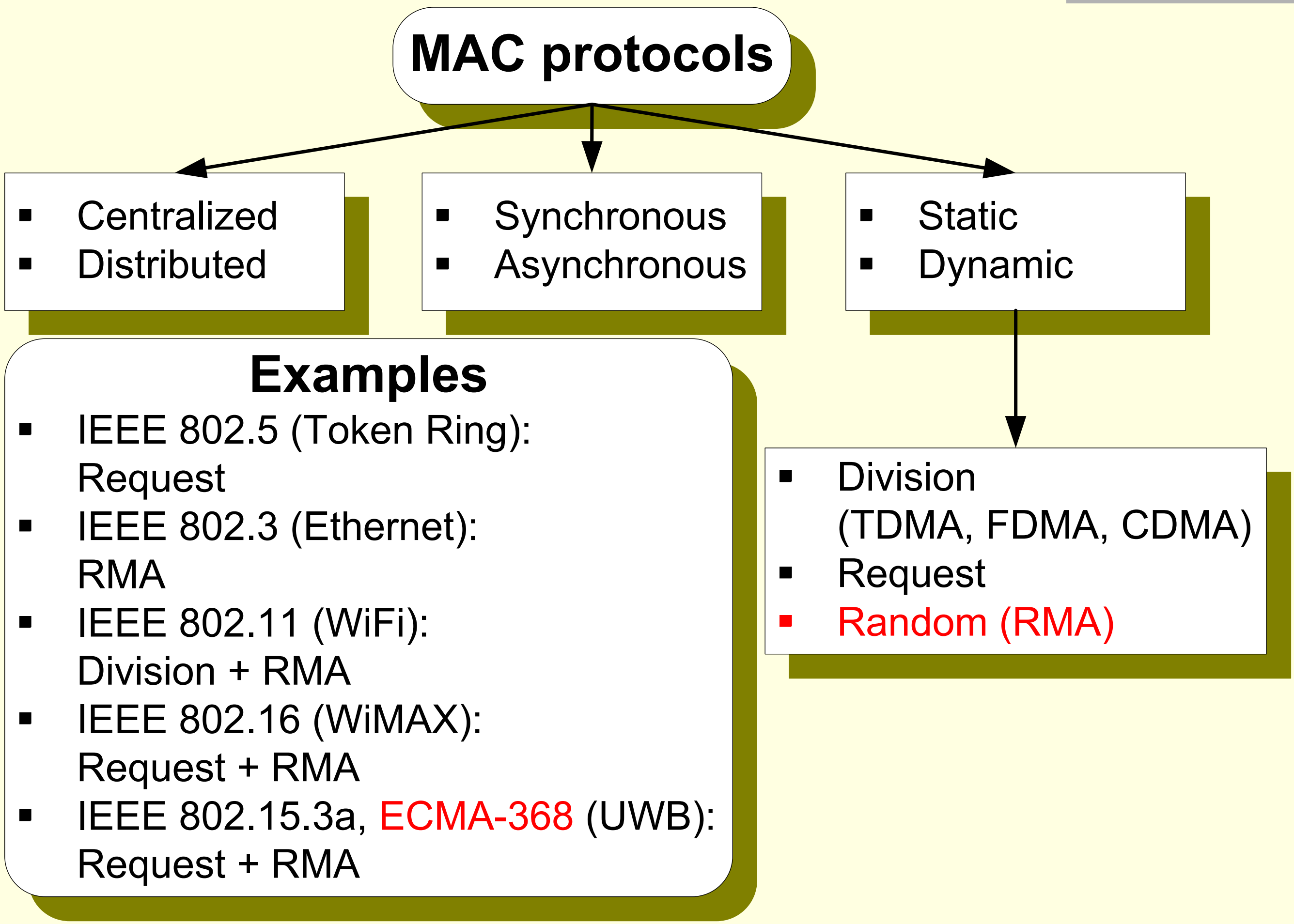
## Characteristics

- MB-OFDM – up to 480 Mbps for 3m WPAN
- DS-UWB – up to 1 Gbps for 1m WPAN

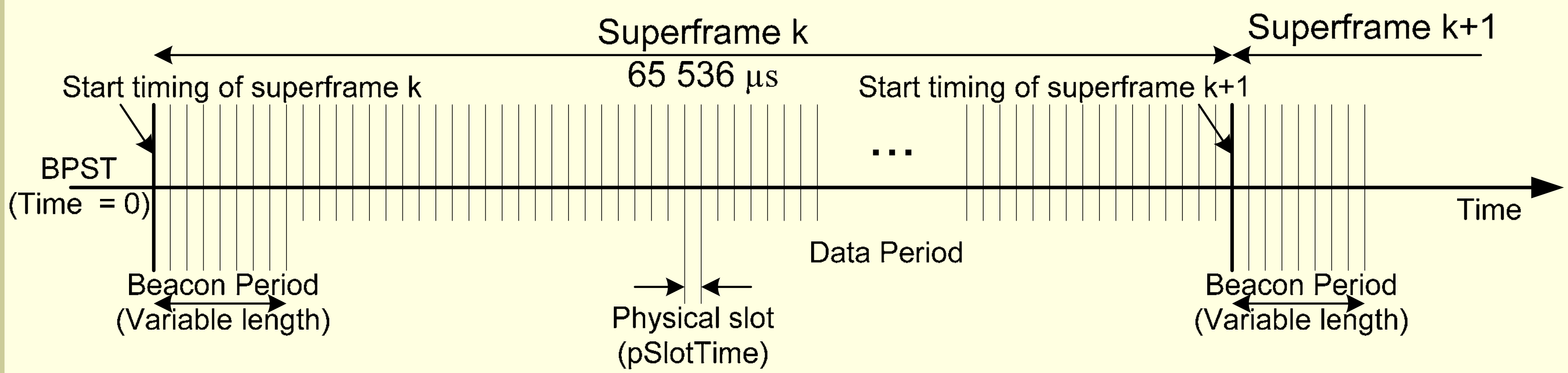
# OSI Reference Model

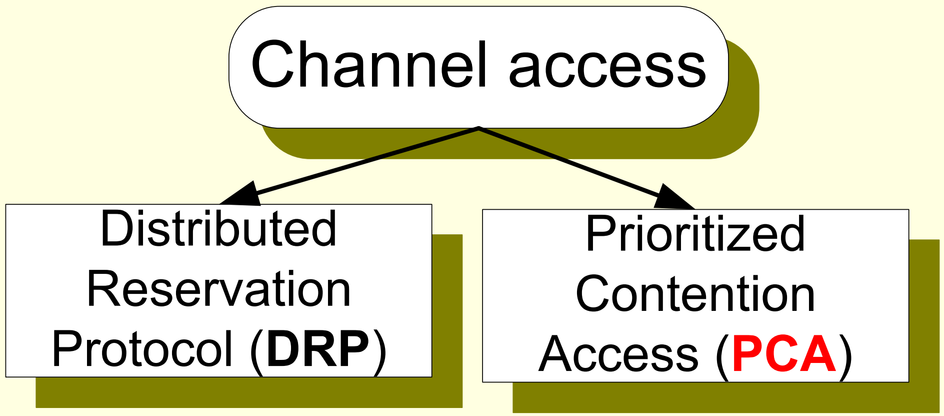


# MAC Protocols

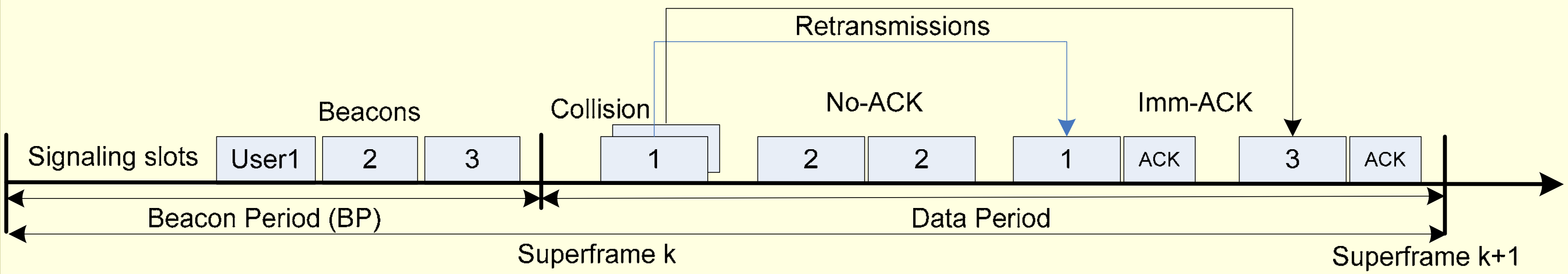


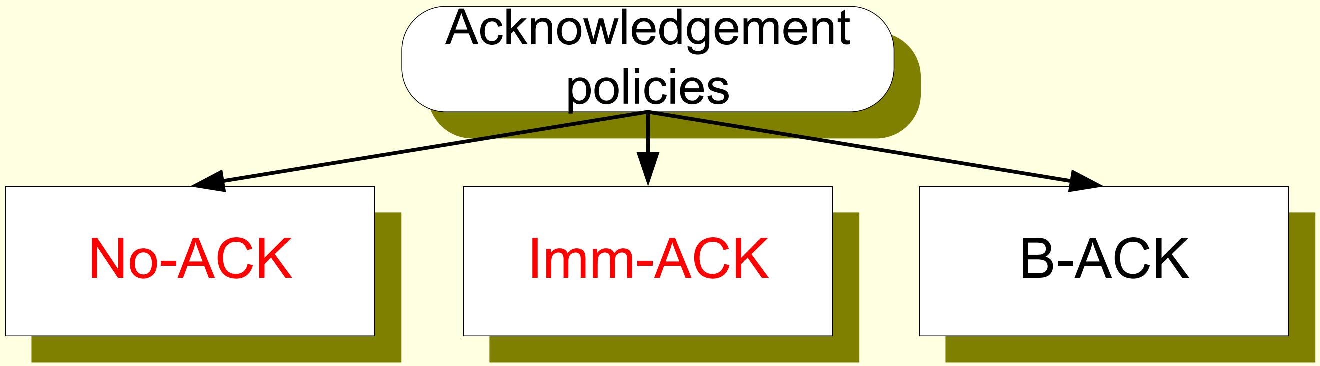
# Superframe Structure



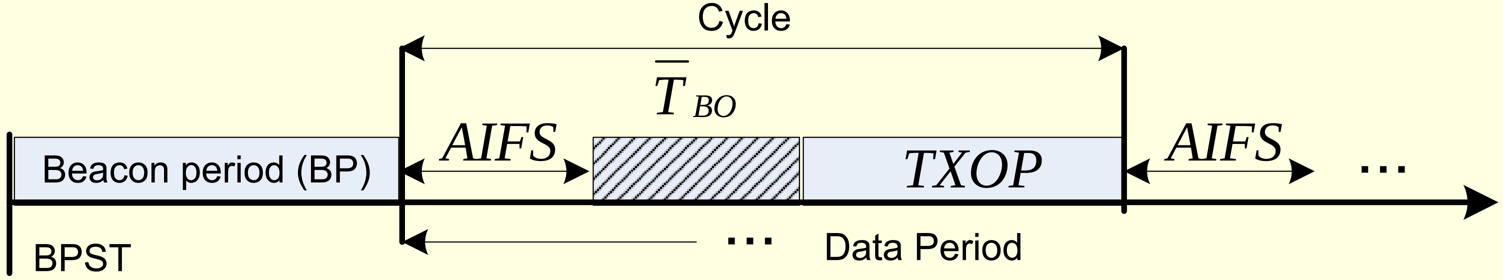
# PCA Channel Operation



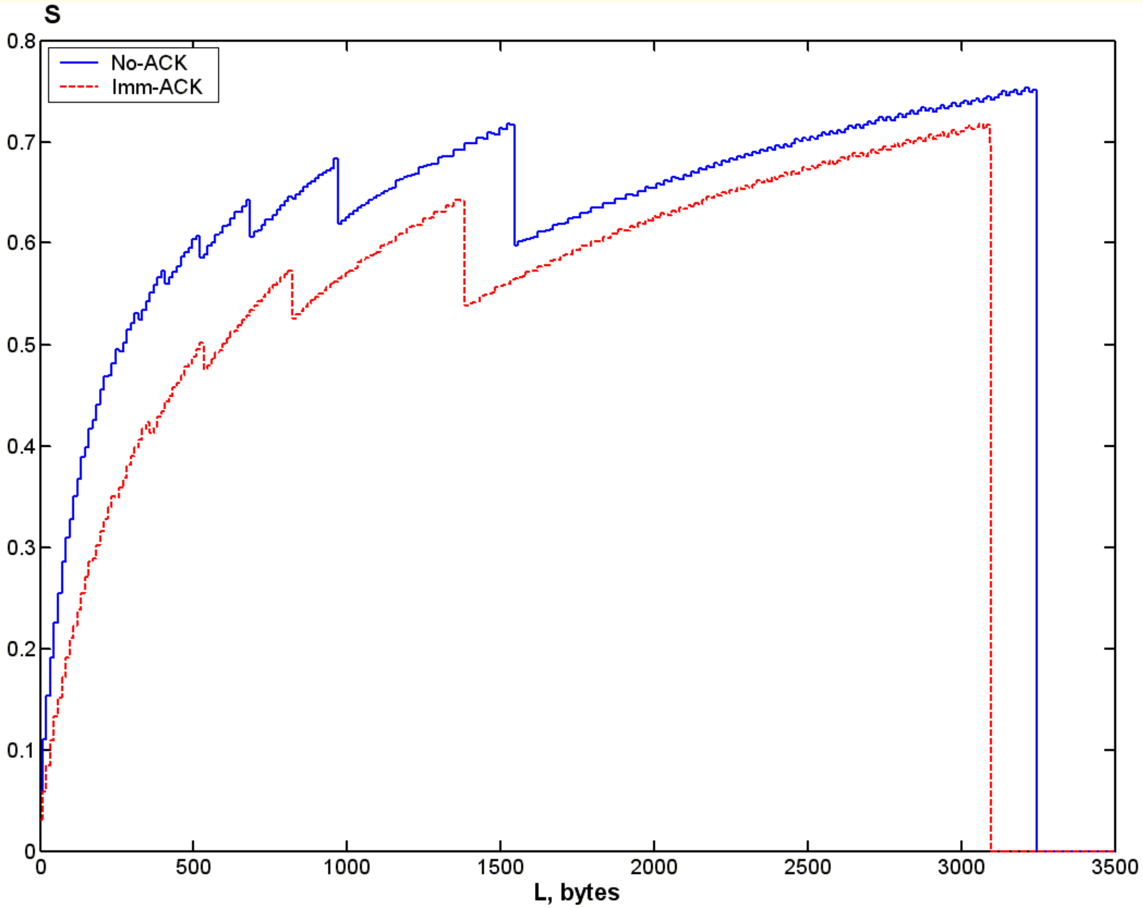



# Simple System Model

- Saturation conditions
- Noiseless channel
- No-ACK, Imm-ACK policies
- Single sender + single receiver
- System throughput (S)?
- Consider superframe regeneration
- Consider cyclic behavior

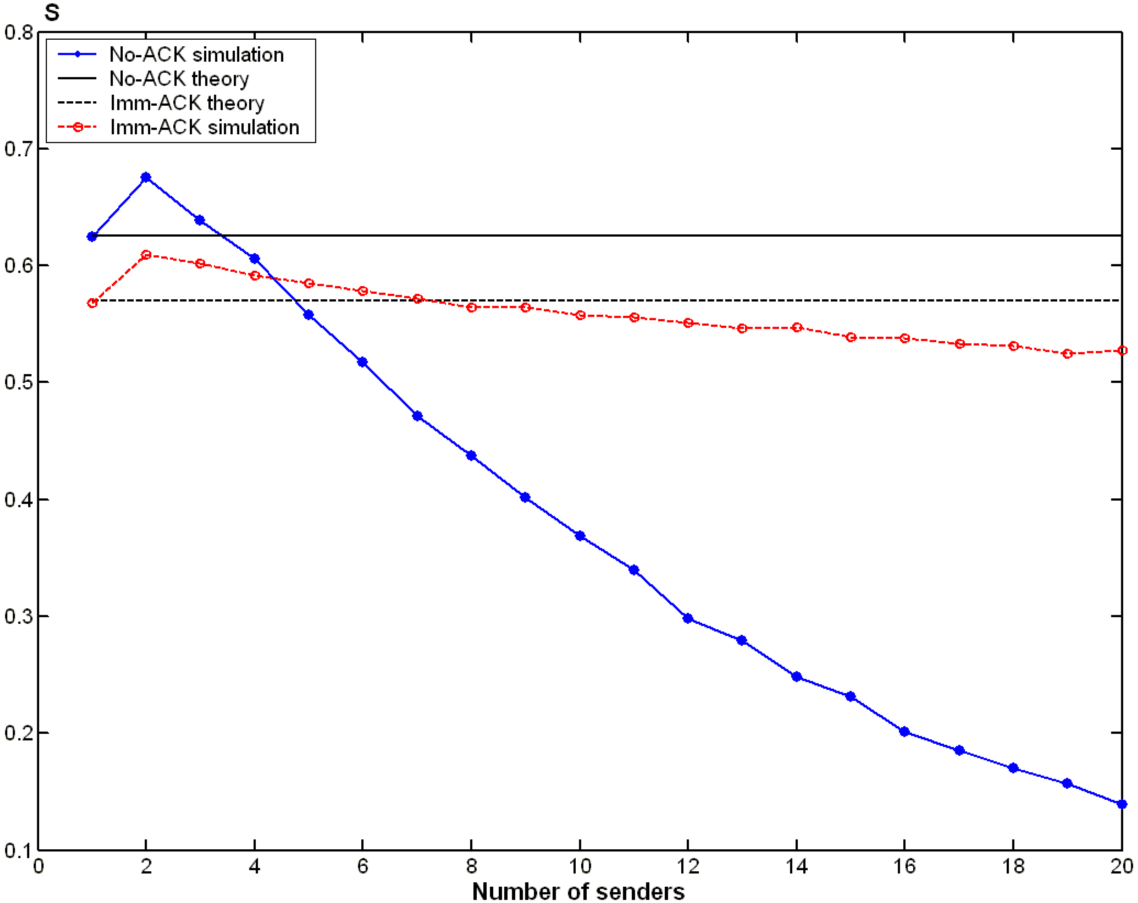


# Simple Results I: S vs. L




Theoretical throughput for one sender S vs. message length L. BK priority, R = 53.3 Mbps

# Simple Results II: S vs. N




Theoretical throughput S for one sender vs. simulation results for the different number of senders N.

L = 1 000 bytes,

BK priority,

R = 53.3 Mbps.

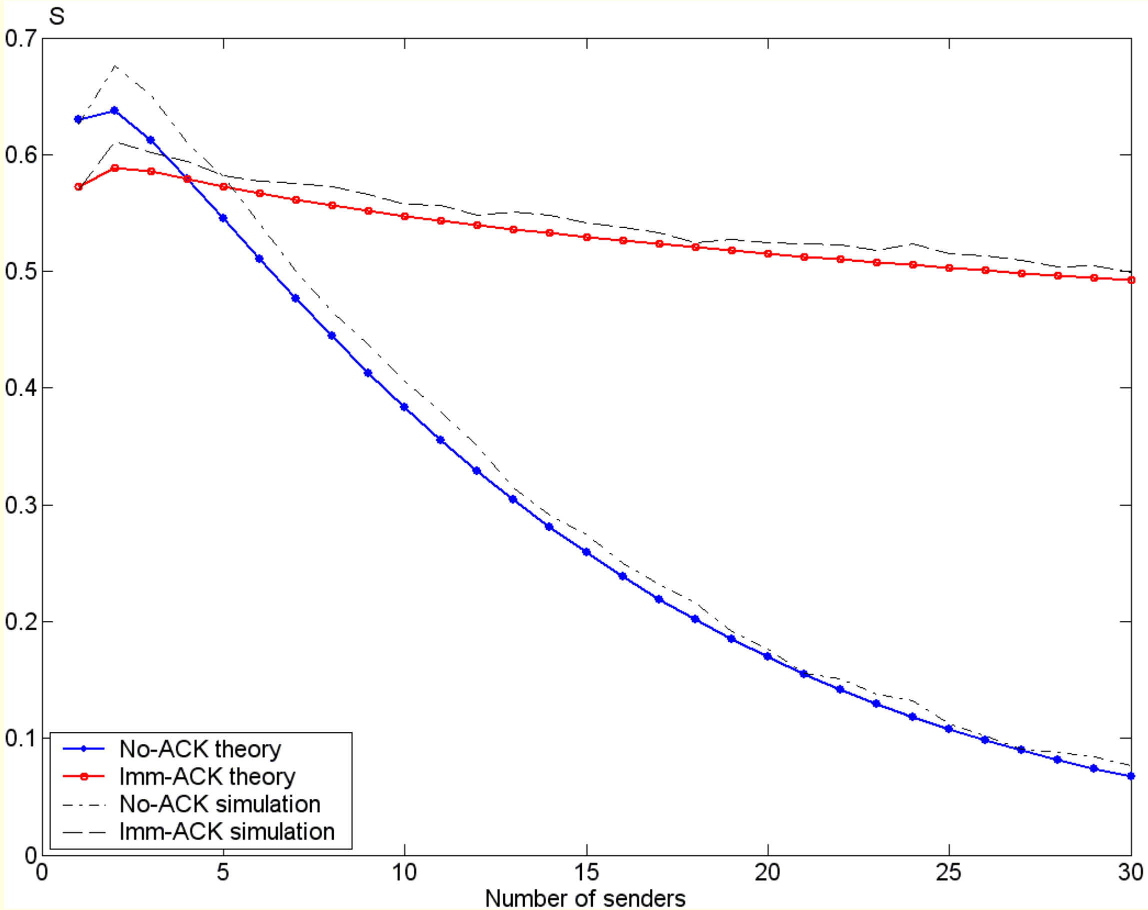
# Advanced System Model

- Message arrivals
  - Saturation conditions
  - Constant input intensity λ
- Noiseless channel
- N equivalent users
- No-ACK, Imm-ACK policies
- System throughput (S) and initial delay ($D_0$)?

# Derivation Process

- Basic assumptions
  - No superframe borders
  - Non-equal slots (empty, collision, success)
  - Constant collision probability (p)
  - Independent transmission probability (π)
- Solve non-linear system of equalities for π
- Derive throughput (S) as a function of π
- Consider asymptotic $\lambda \rightarrow 0$ case
- Derive $D_0$ as message delay in empty system

# Advanced Results I: S vs. N



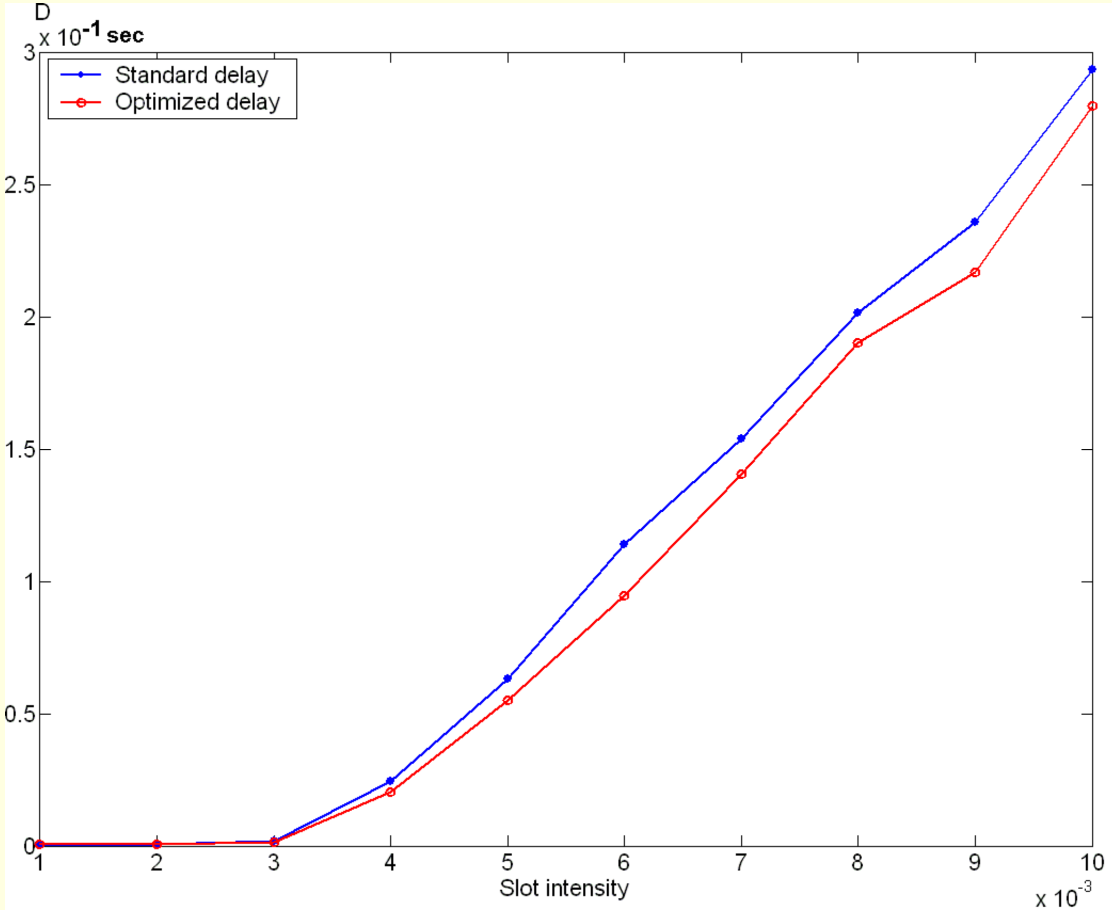

Theoretical throughput S vs. simulation results for the different number of users N.

L = 1 000 bytes, BK priority, R = 53.3 Mbps.

# Performance Optimization

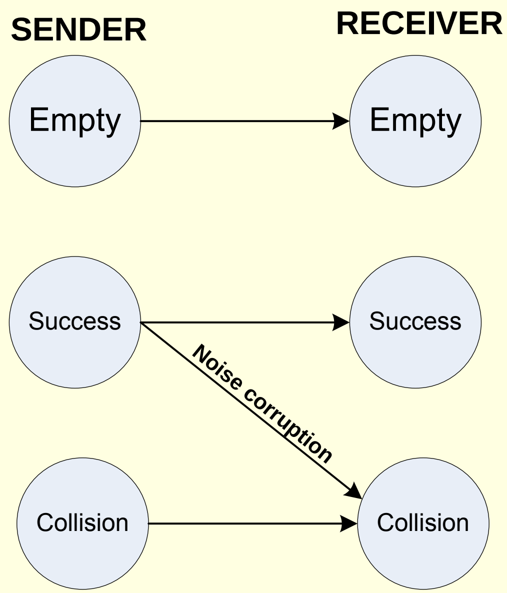
- Obtain current number of users (beacons)
- Maximize throughput function
- Derive optimal π value
- Find optimal backoff parameters
- Compare with existing ones
- How does delay change?

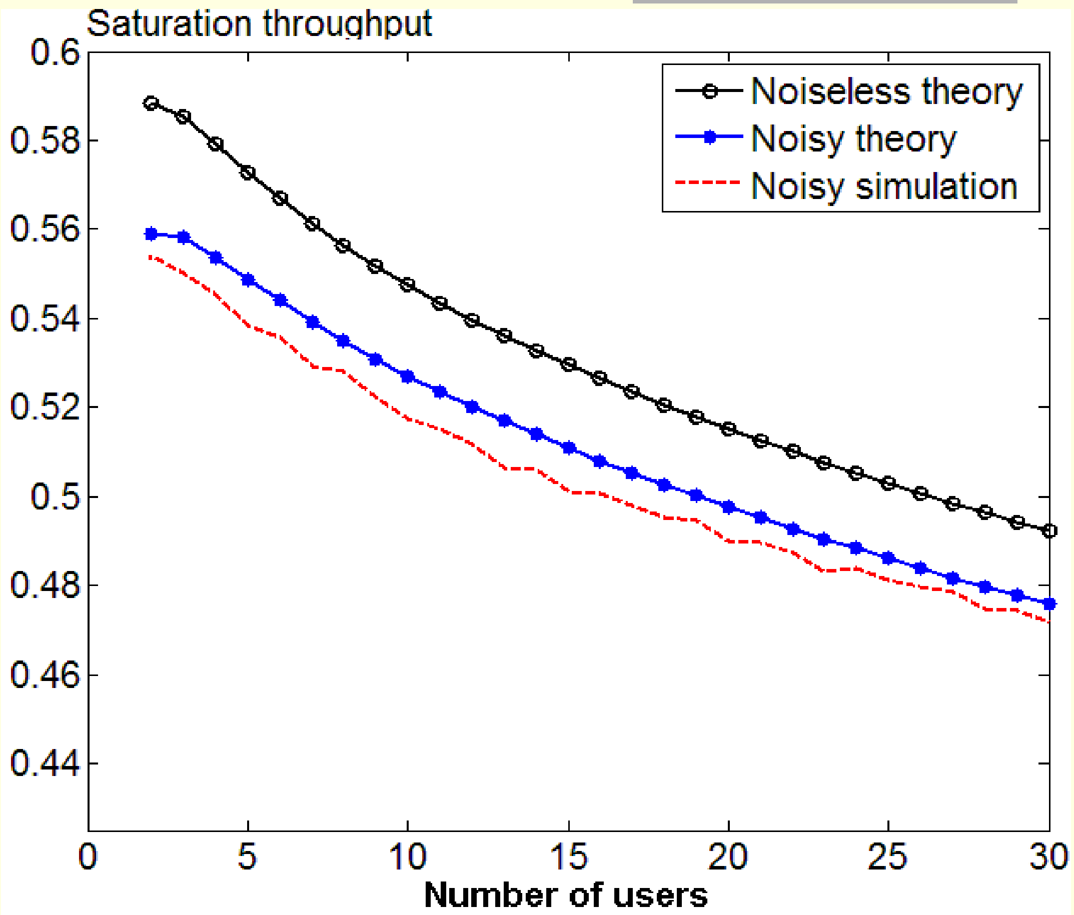
# Advanced Results II: D vs. λ



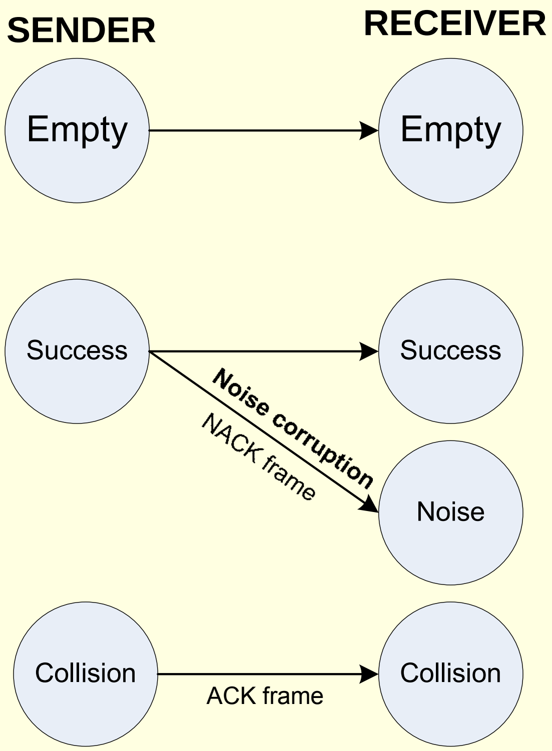

Simulation mean delay for standard and optimized systems,
L = 1 000 bytes,
BK priority,
R = 53.3 Mbps.

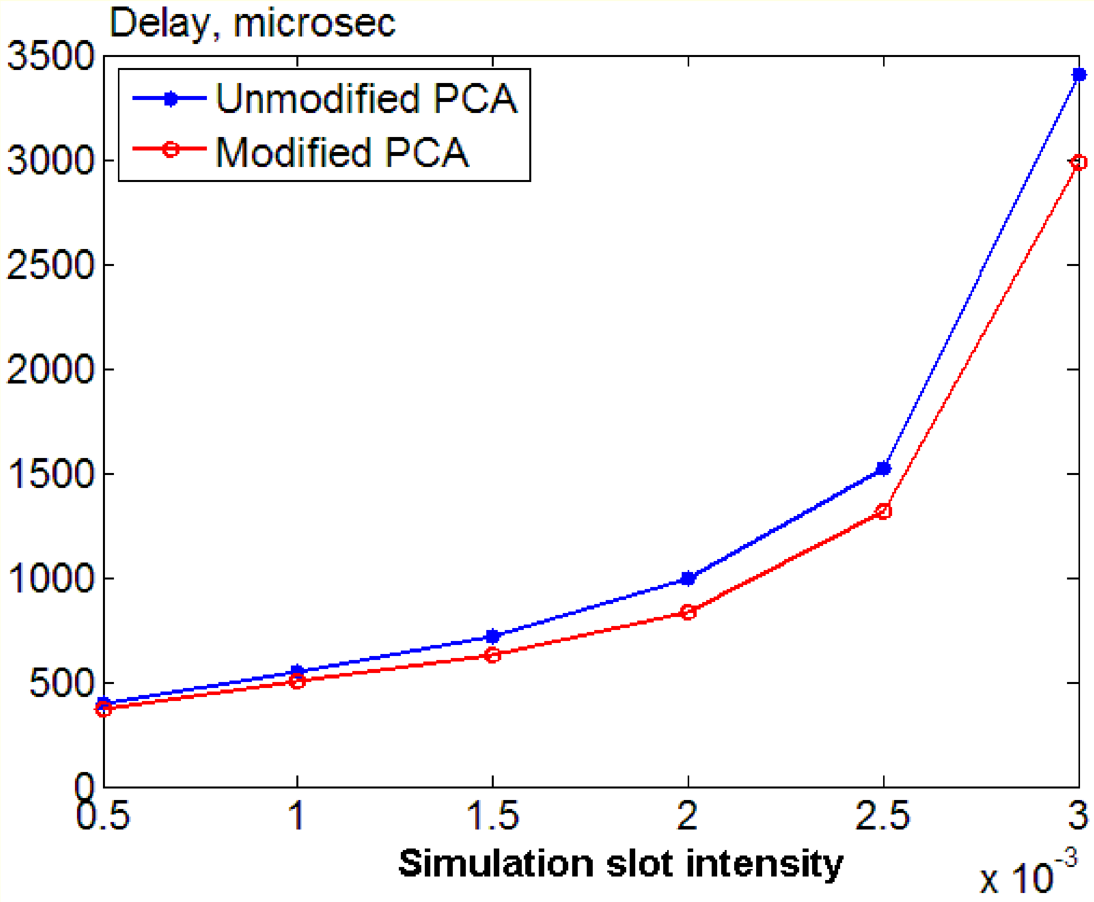
# Noisy Channel Consideration



# ‘Negative Acknowledgements’



# Summary and Publications

- Summary
  - 2 ways of throughput estimation
  - Initial delay estimation
  - Noisy channel consideration
  - Random access algorithm performance optimization
  - ECMA-368 Standard modification
- Papers submitted - 2007
  - 2 papers: SUAI scientific conference
  - 1 paper: III ISA European students paper competition
  - 2 papers: International conferences acceptance