Performance Evaluation of an Integrated-service IEEE802.11 Network

COE541 Course Project
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Outline

- Overview of IEEE 802.11 Standard
- IEEE 802.11 Distributed Coordination Function
- Project Description
- Assumption & Methodology
- Simulation Results
- Concluding Remarks

Overview of IEEE 802.11

- Specifications for MAC & Physical layers in wireless LANs
- Some PHY implementation:
  - Original IEEE 802.11
    - DQPSK, DBPSK, GFSK @ *2.4GHz ISM band* ➔ *1 & 2 Mbps (DSSS or FHSS)*
  - IEEE 802.11b
    - CCK @ *2.4GHz ISM band* ➔ *11 Mbps*
  - IEEE 802.11a
    - OFDM @ *5GHz band* ➔ *54 Mbps*

Overview of IEEE 802.11

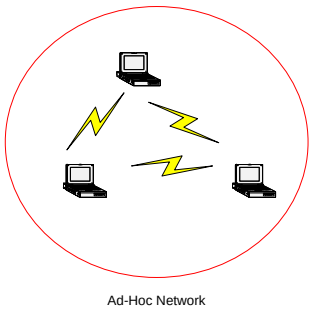
- MAC Protocol:
  - Carrier Sense Multiple Access / Collision Avoidance (CSMA / CA)
    - Physical carrier sensing (RSS or valid-bits)
    - Virtual carrier sensing (NAV)
  - Two Modes:
    - Distributed Coordination Function (DCF)
      - No central control of the wireless medium
      - Listen before talk: – If channel free ➔ transmit
        – If channel busy ➔ back-off
    - Point Coordination Function (PCF)
      - Central coordinator controls the medium
      - If channel is reserved by PC ➔ wait until allowed to transmit
      - If channel not reserved ➔ same as DCF (listen-before-talk)

Overview of IEEE 802.11

- Topology:
  - Basic Service Set (BSS):
    - Two or more wireless hosts
  - Infrastructure:
    - Two or more BSS & a Distribution System (DS)
    - Each BSS use an Access Point (AP) to connect to DS
  - Add-Hoc:
    - A stand-alone BSS not connected to a DS

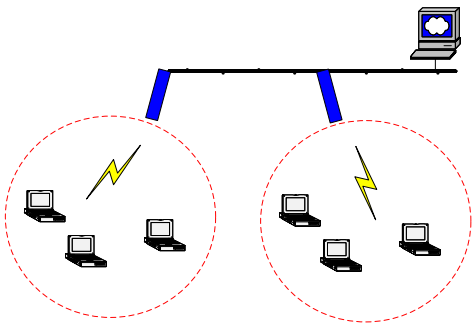
Overview of IEEE 802.11

Add-Hoc Network



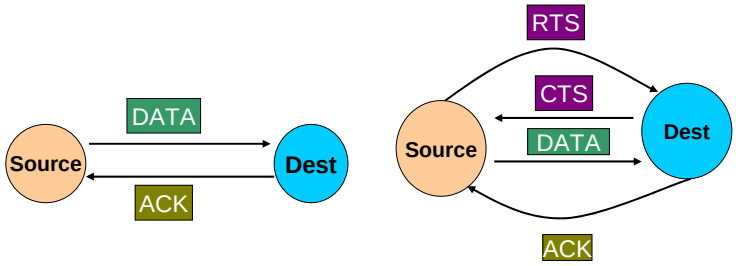
Ad-Hoc Network

Infrastructure Network



IEEE 802.11 DCF

- Two access techniques
  - Basic mechanism: 2-way handshaking
  - RTS/CTS mechanism: 4-way handshaking

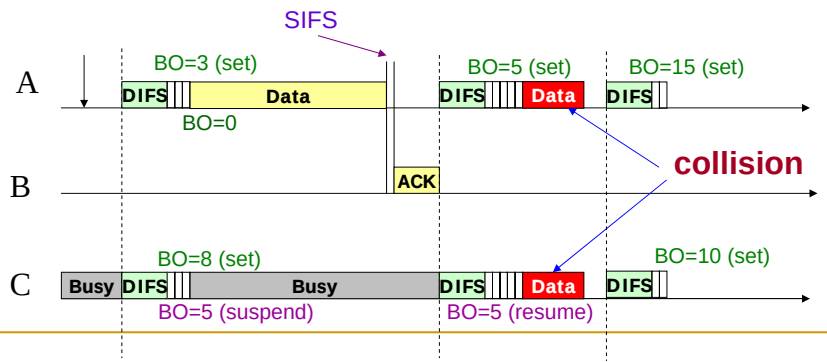


Basic Access Scheme

Basic DCF:

Before transmit:

Sense, if channel busy ➔ defer until channel free ➔ wait DIFS (channel to remain free) ➔ generate back-off ➔ decrement back-off as long as channel remains free ➔ transmit when back-off reaches zero

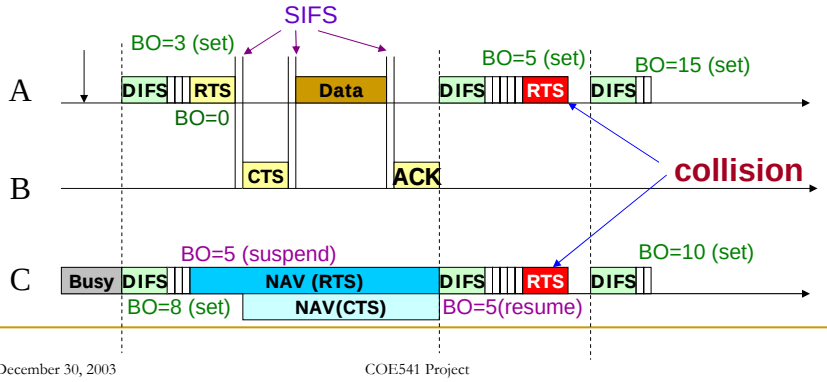


RTS/CTS Access Scheme

RTS / CTS:

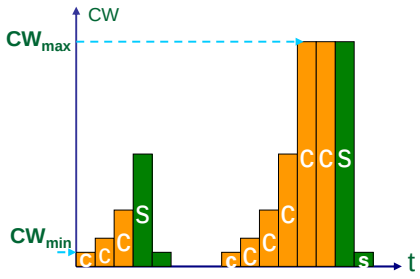
Before transmit:

Source uses basic DCF for first packet only, i.e. RTS packet ➔ Destination confirm by CTS ➔ Once access is granted, reserve the channel for the Data packet using NAV signal until ACK is received



Back-off Counter

- Binary Back-off procedure
  - Initially, uniformly generated from (0,CW-1] , CW = CWmin
  - Decremented every time slot when the channel becomes free
  - Frozen when the channel becomes busy
  - CW is doubled after every collision until it reaches CWmax
  - After every successful transmission, CW is reset to CWmin



Project Description

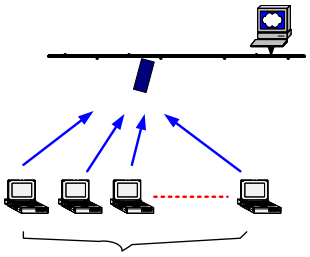
- IEEE 802.11 Wireless LAN
  - Can operate in two modes:
    - contention-based access (Basic DCF)
    - Contention-free access (RTS/CTS)
  - N mobile stations (two classes) and one AP
    - Nodes from class 1 produce real-time traffic
    - Nodes from class 2 produce non-real time traffic
- Problem ?
  - Build a model for the traffic generator for the two classes of nodes
  - Evaluate performance in both access modes by simulation

How ?

- Divide the problem into two parts:
  - Part I:
    - Contention-based Access, Basic DCF
    - Non-real time traffic, data
  - Part II:
    - Contention-free Access, RTS/CTS
    - Class 1 nodes produce only real-time, voice
    - Class 2 nodes produce only non-real time traffic, data

Assumptions

- Network:
  - Infrastructure topology
  - IEEE 802.11b ➔ DSSS, 11Mbps



Assumptions

- We assumed:
  - All nodes traffic is directed to AP only
  - AP has no central role & acts only as a destination
  - No traffic is generated by AP
  - ACK packets are not simulated
  - Propagation delay is not simulated
  - Time is slotted
  - No hidden terminals

Methodology

- Time-driven Simulation
  - Define all possible states of all nodes
  - Define all possible state transitions & their conditions
  - Design the state-machine algorithm
- Implement using MATLAB
  - Generate traffic ahead of time
  - Run the state-machine process
  - Collect the performance variables

Part I

Basic DCF

- Traffic Generator:
  - Fixed-size data packet
  - Bernoulli's arrival distribution;
    - With probability P, a node has a packet in a time slot
    - For every node, generate a uniform random number and compare it with P
    - Repeated for all simulation time ➔ arrival matrix
  - All nodes identical; same P

Station	Data Packet Arrival										
1	0	0	0	**1**	0	**1**	**1**	0	**1**	0	0
2	0	**1**	0	**1**	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	**1**
4	0	0	0	0	**1**	0	0	0	0	0	0

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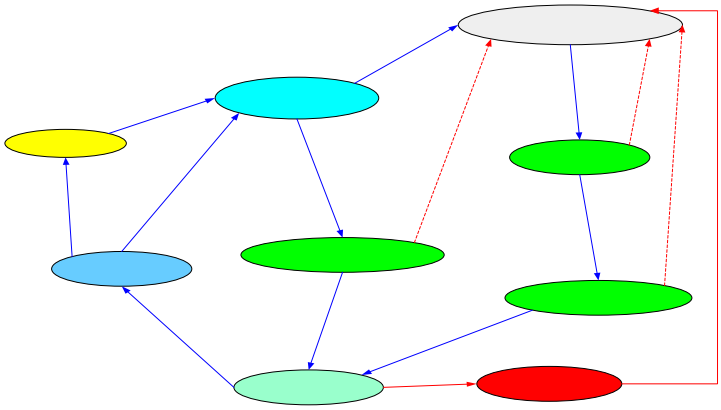
Basic DCF

- States' Definition:

State	Name	Definition
0	*idle*	packet queue is empty
1	*packet_ready*	packet queue is not empty
2	*waiting_free_medium*	node has packets but the medium is busy
3	*waiting_DIFS_only*	node is waiting for DIFS period of time (on first check, medium found free)
4	*waiting_DIFS*	node is waiting for DIFS period of time (on first check, medium found free)
5	*waiting_backoff*	node is waiting for back-off timer
6	*sending_data*	node is now sending data
7	*data_collision*	node has encountered a collision
8	*packet_sent*	node has transmitted the packet successfully

Basic DCF

- State Transitions:



Basic DCF

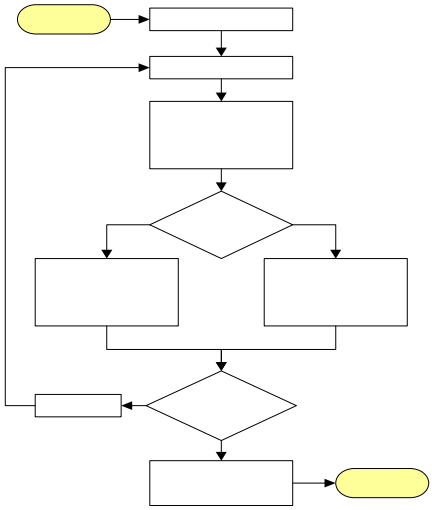
- State Machine:
  - Imaginary daemon that scans the states of all nodes and update them according to the medium status
  - Scan repeated every time slot
  - Keep track of all cumulative output variables
- Timing Parameters:
  - 1 time slot = 10 µsec
  - SIFS = 2 slots
  - DIFS = 6 slots
  - Packet time = 10 slots ~ 140 Bytes
  - CWmin = 32 slots
  - CWmax = 1024 slots

idle

queued = 0

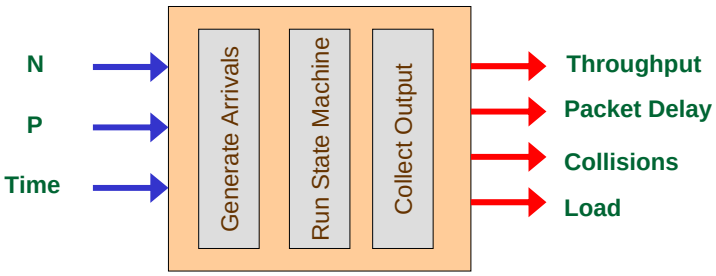
pack

Main Algorithm



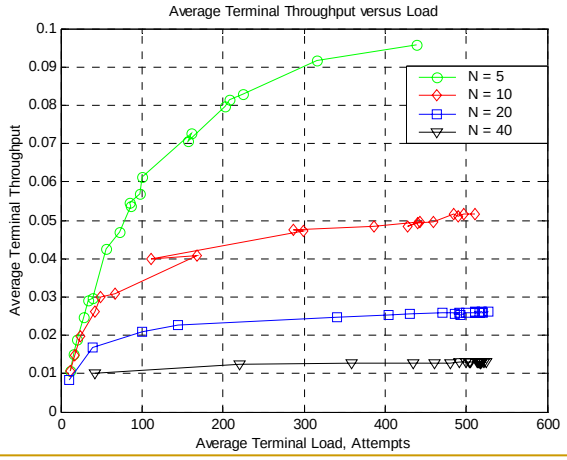
Simulation Program

- How we run it ?



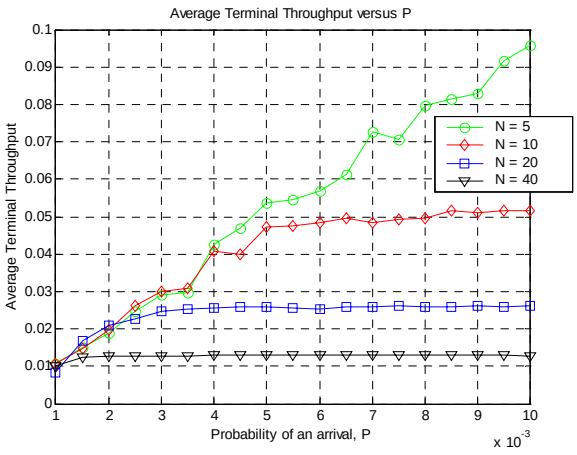
Simulation Results

- Average Terminal Throughput:



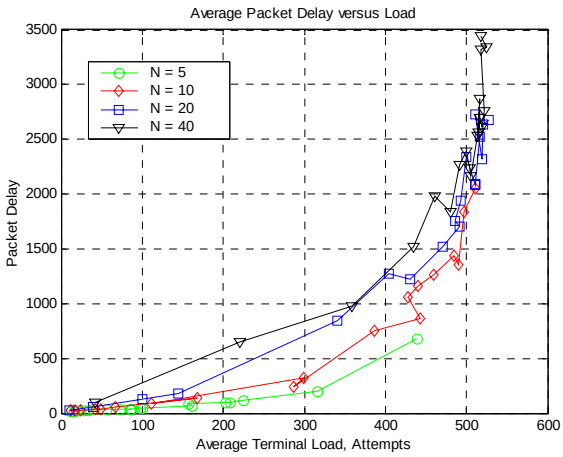
Simulation Results

- Terminal Throughput – P :



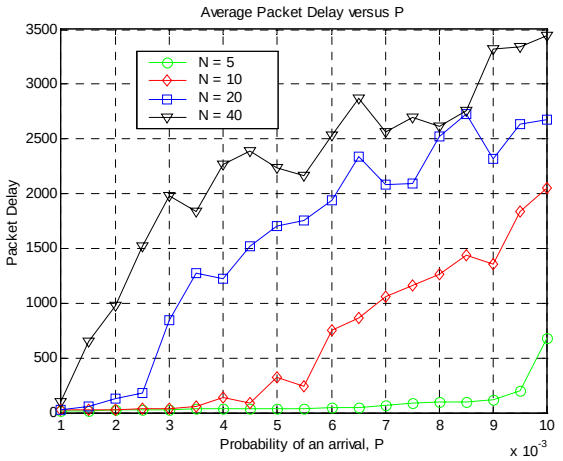
Simulation Results

- Average Packet Delay:



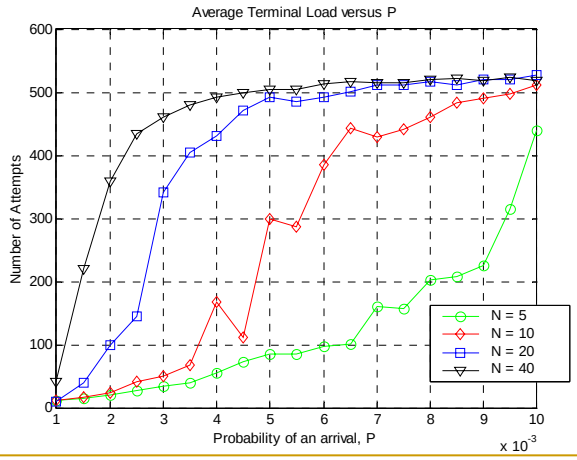
Simulation Results

- Packet Delay - P:



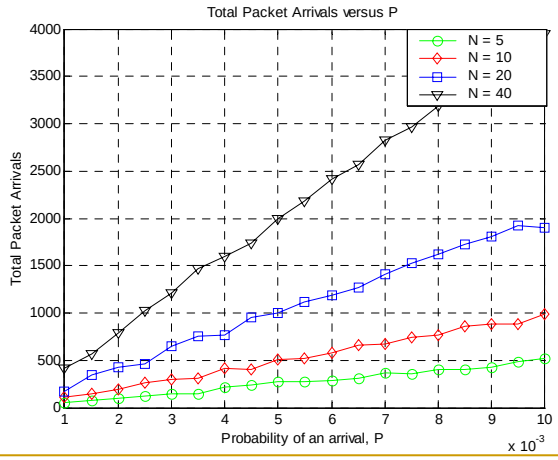
Simulation Results

- Average Load: Attempts per time slot



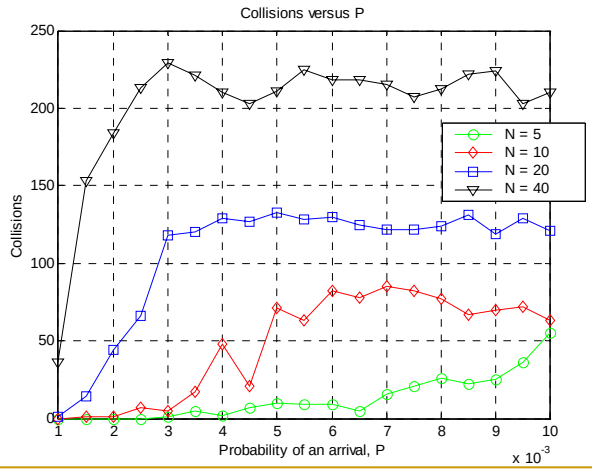
Simulation Results

- Offered Load: Total packet arrivals



Simulation Results

- Collisions



Remarks

Part II