DFWMAC

Distributed Foundation

Wireless Medium Access Control

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Background

- Previous proposals: WMAC (NCR/Symbol), WHAT (Xircom)
- "Family resemblance", distributed CSMA/CA foundation
- DFWMAC is combined approach, drawing best ideas from source proposals
- This presentation provides overview - subsequent presentations will cover access method (contention and contention free), synchronization and scanning

DFWMAC Protocol Characteristics

- Distributed and Point Coordination Functions
- Asynchronous and Time Bounded Services
- PHY-independence: single and multiple channel environments, multi-bitrate provisions
- Infrastructure and Ad Hoc networks
- Multiple systems can overlap in the same channel
- Power Management provisions
- Distributed or centralized synchronization

Applications Supported

Current wired LAN applications

- Support wireless network for flexibility
- Support major network operating systems

Mobile computing

- Support Low Power operation for battery operated devices like Notebooks and PDAs

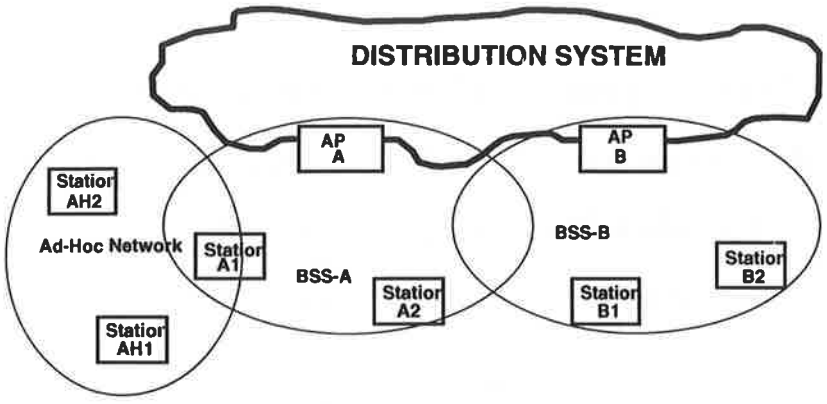
Time-bounded services such as voice

- Medium efficiency with variable rate applications

PHYs Supported

- Direct Sequence, Infrared, Frequency Hopping
- Multi- or single-channel
- MAC should be applicable to PCS, HIPERLAN, ...
- Multiple bitrate PHYs

Wireless Network Architecture



- Collection of infrastructure BSS's forms ESS
- Ad Hoc BSS can overlap with Infrastructure

BSS, ESS Identifiers

Each ESS is identified by an ESS-ID

Each BSS (within an ESS) is identified by BSS-ID

Together these form the "Network ID" which is a field within frame format

Ad Hoc, Infrastructure indicator

Association and Re-association (Infrastructure)

Authenticated station generates "Associate Request" frame

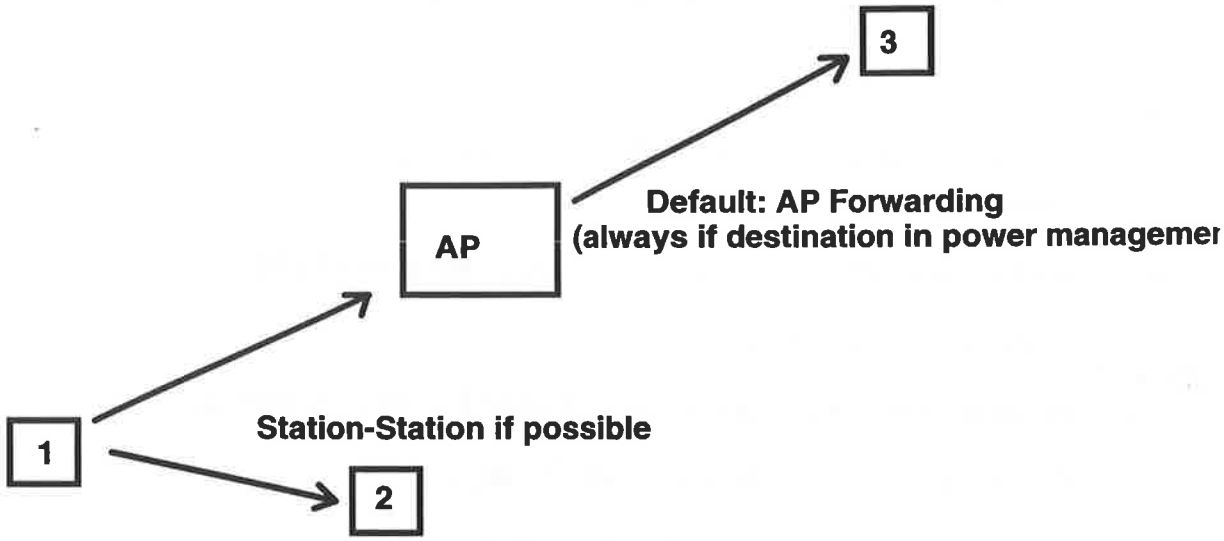
- Include parameters indicating requested service, ...

Access Point responds with "Associate Response"

- Response parameters include Beacon Interval, Station ID, ...

In case of re-association, APs may coordinate handoff via Distribution System

BSS Data Transfers (Infrastructure)



DFWMAC Coordination Functions

Distributed Coordination Function: CSMA/CA

- **Basic access method (the "foundation")**
- **Parametrized use of RTS/CTS**
- **Ad hoc and infrastructure, always available**

Point Coordination Function

- **Compatible with CSMA/CA**
- **Supports time bounded and asynchronous services**
- **Optional, available only in certain infrastructures**

CSMA with Collision Avoidance

Station with frame to transmit defers to current transmission

Collision avoidance - when medium becomes available:

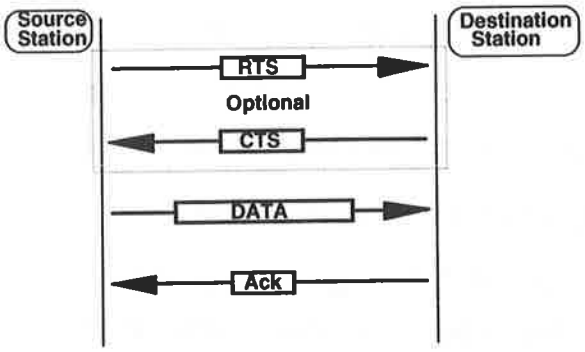
- select random interval
- ensure medium remains available for that interval
- if yes, transmit, otherwise defer again

Subsequent attempts use longer randomization

Aspects of CSMA/CA Algorithm

- Preference to stations which have waited longer
- Multiple Inter-frame Spaces defined, allows prioritization of traffic classes
- Certain situations involve RTS/CTS for improved hidden station protection
- Physical CS plus "Virtual" CS via Net Allocation Vector

RTS/CTS Exchange



RTS and CTS include "duration" of subsequent data/ack exchange

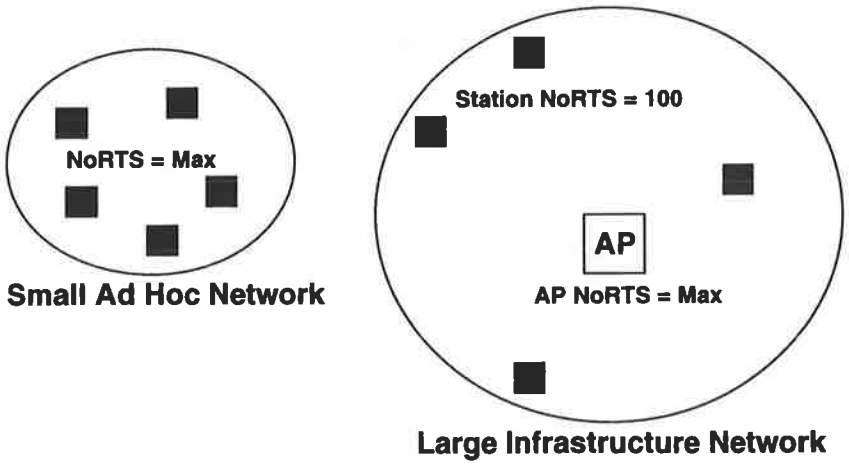
Net Allocation Vector

- RTS and CTS include *duration* field indicating how long the subsequent data transfer is to take
- All stations maintain a *net allocation vector* (NAV) which represents the anticipated state of the medium for the immediate future, updated by RTS/CTS
- Since CTS is transmitted by data destination, medium is reserved in both source and destination neighborhoods
- NAV concept also used for medium protection during contention free transmissions

Parameterized Use of RTS/CTS

- RTS/CTS exchange can reduce collision probability in certain situations
- Hidden station configurations (e.g. station-to-AP)
- Beneficial on long frames, overhead on short
- Approach: per-node *NoRTS* parameter defining minimum frame size transmittable without RTS

Example NoRTS Parameters



PHY with weaker CS would want increased use of RTS/CTS

Interframe Spacing

- Different frames may use different interframe space (IFS)
- Smaller IFS gives medium access priority
- Short IFS < Point IFS < Distributed IFS
- Short IFS used for acknowledgments, RTS, CTS, ...

Frames and MPDUs

An MDPU may consist of a sequence of related frames, such as

- DATA + ACK
- RTS + CTS + DATA + ACK

Same MPDU-ID used in all frames within a given MPDU

16 bit hash of NetID, Source Address, Sequence Number

MAC-Level Acknowledgment and Retransmission

- Increase robustness of wireless medium
- Used for directed asynchronous transfers (and multicast from stations that are forwarded by AP)
- Short IFS used, MPDU ID ties together data with subsequent ack
- Duplicate filtering based upon MPDU ID
- Exponential backoffs for retransmissions

Synchronization of BSS

- Required for power management, contention free and time bounded support, PHY management (FHSS)
- Infrastructure: AP acts as timing master via periodic *beacon* generation
- Ad Hoc: distributed beaconing
- Beacons define common time reference within BSS
- Power management complicates the process of establishing and maintaining synchronization
- Complicated by out-of-range stations

Synchronization Compatible with CSMA and Overlapped Nets

- Can't require that a frame transmission *must* occur at specific time
- Solution: Beacons may be deferred - but contain time value at instant of transmission
- Not necessary to hear every beacon: used for recalibration of station clock

Scanning and Acquiring Synchronization

Wide variety of different situations

- Different PHYs (number of channels, etiquettes)
- Ad Hoc versus Infrastructure
- Power Management

DFWMAC Approach: define a set of mechanisms which can be applied in various cases

DFWMAC Scanning Mechanisms

Clock adjustment or adoption upon receipt of a timestamp

- "Weight" concept useful in ad hoc case

Passive scanning

- Periodic Beacon generation
- APs (infrastructure) or distributed beaconing (ad hoc)

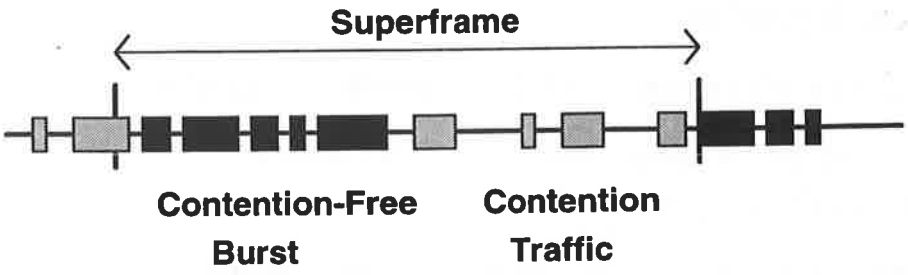
Active scanning

- Probes with Probe Responses

Contention Free Access

- Point coordinator (AP) seizes control through higher PIFS access priority (infrastructure only)
- Superframe: contention-free and contention periods
- Contention-free burst (up, down, or station-station) managed by point coordinator and protected by NAV
- Unused contention-free bandwidth automatically becomes available for contention users
- Point coordinated BSS can overlap with distributed BSS but not with another point BSS on same channel

Superframes



Contention-Free Applications

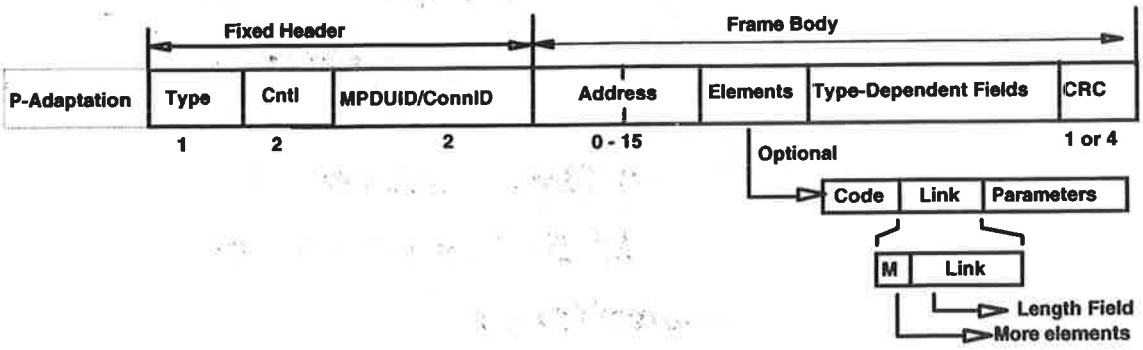
Time-Bounded Service

- **Guaranteed regular transmit opportunities**
- **Handles variable data rates, frame sizes, traffic requirements**

Asynchronous Service

- **Adjunct to contention asynchronous service**
- **Performance boost for multi-frame transmissions**
- **Time-bounded takes precedence**

Basic Frame Format



Frame Fields

PHY-Adaptation: PHY-specific MAC information (if required)

Type: Frame Type plus indicators

- **Encrypted and/or Compressed**
- **Asynchronous or Time-Bounded**

Control: Includes control bits for various functions, such as

- **Power Management Mode**
- **To/From AP or Station**

Frame Fields (continued)

MPDU ID: for duplicate detection, ConnID in case of TBS

Address: may include NetworkID, Destination Address, Source Address

Elements: optional elements (e.g. TIM, timestamp, ...)

Type-Dependent Fields: e.g. "Data" field for Data frame

CRC: 32 bit, 8-bit for short control frames

Frame Types

Asynchronous
- RTS
- CTS
- Data
- Ack
- Poll
- Beacon
- ATIM
- Request
- Response

Time Bounded
- TB-Up
- TB-Down
- TB-CTS
- TB-Ack

Conclusions

Distributed Foundation Wireless Medium Access Control

- **Basic CSMA/CA applicable in all configurations**
- **Virtual carrier sense mechanism**
- **Optional Point Coordination Function supporting both Time Bounded and Asynchronous services**
- **Synchronization and scanning mechanisms**
- **Power Management provisions**
- **PHY-independence**