WMAC Protocol

More Details

Synchronization and Power Management Mechanisms

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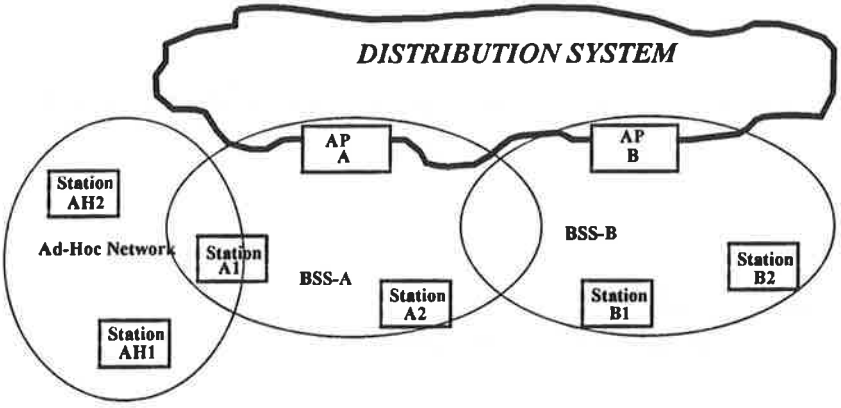
Background

- Represents joint contribution to IEEE by Symbol and NCR (competitors driven towards compatibility by customers)
- Different from both companies' current products
- Basic CSMA/CA and Time-Bounded aspects already presented
- Focus here on synchronization and power management

Wireless Network Architecture



- Infrastructure mode: supports single channel PHY
- Ad-Hoc mode: can overlap with Infrastructure

WMAC Protocol Characteristics:

- Distributed Access Protocol based on CSMA/CA + Ack
  - Efficient medium sharing
  - Robust for interference
  - Support Asynchronous and Time Bounded Services
- Support single and multiple channel environments
- Support Infrastructure and Ad-Hoc networks
- Multiple systems can overlap in the same channel
- Includes specific provisions for Power Management

Applications Supported

Mobile computing

- **Support Low Power operation for battery operated high speed data transfer devices like Notebooks**

Messaging/Transaction Systems

- **Support extreme low power devices like PDA's that can use the network infrastructure**

Current wired LAN applications

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

Time-bounded services

Power Management Principles

- **Application independence**
- **Turn transceiver off (sleep mode) as much as possible**
- **Transmitter buffers frames and periodically transmits short announcements to receivers**
- **Receivers need only listen for announcements until presence of incoming frame is detected**
- **Transmitter and receiver synchronization allows for substantial power conservation with acceptable performance**

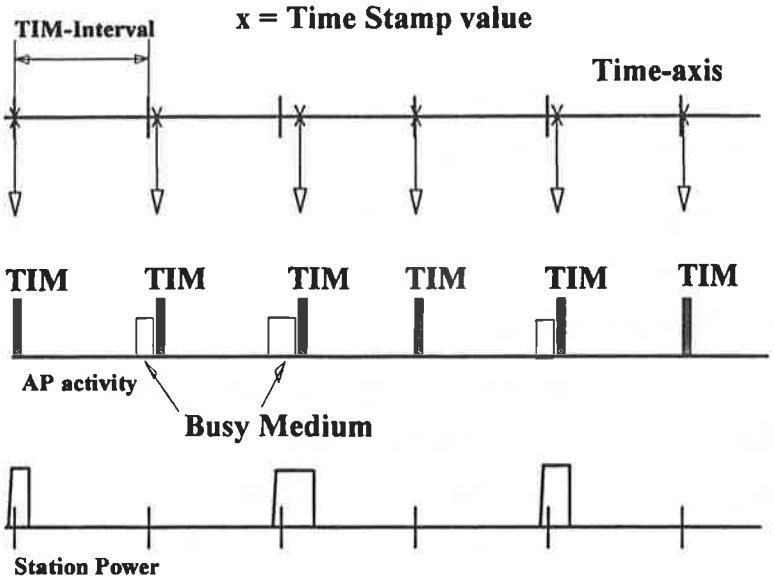
Power Management Methodology

- Synchronize all stations to a "Timing Coordinator"
  - AP in Infrastructure Networks, or an assigned station in ad hoc
- Stations can be in different PM-modes and can dynamically switch modes
  - CAM: Continuous Active Mode
  - PSM: Power Save Mode (various flavors)
- Transmitters know the PM-mode of the receivers
- Transmitters send "Traffic Information Message" (TIM) at regular intervals indicating buffer status

Synchronization Methodology

- Free running Timer in "Timing Coordinator"
- Timestamp transmitted at regular intervals (in TIM)
  - Timestamp is timer copy at *actual medium access time*
  - All receivers within BSA load timestamp (plus modem delay correction) in local timer
- The TIM interval Timer keeps running in "Doze" state

Synchronization



Station Power Save States

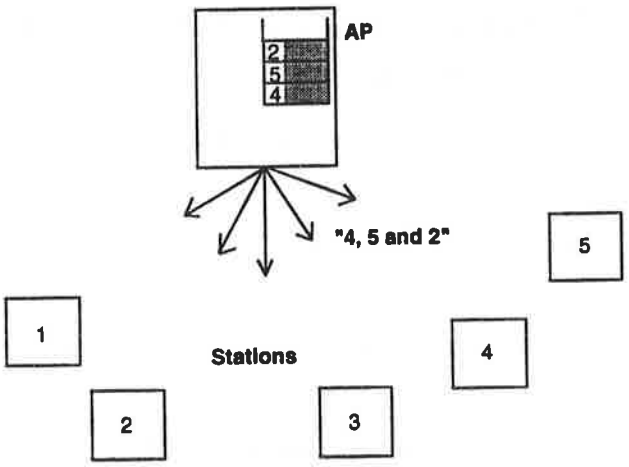
- *Transmit* State: Transmitter is turned On
- *Awake* State: Receiver is fully powered and capable of receiving
- *Doze* State: Transceiver is not able to transmit or receive, and consumes very low power. TIM interval Timer active.

Stations using Power Save mode will cycle from *Doze* to *Awake*, only when relevant traffic is expected, or just before a transmission starts. CAM stations will be continuously *Awake*.

Infrastructure Power Management

- AP buffers the traffic for stations that are in Power Save Mode
  - AP knows the PM-mode per station (PM-bits in Header)
  - Broadcast traffic is also buffered
- Two different Power Save Modes available:
  - PSNP Power Save Non-Polling
  - PSP Power Save Polling
- AP broadcasts the buffering status at regular intervals
  - In separate TIM packet every 20-50 msec
  - Possibly embedded in Frame Header as element
  - DTIM (Delivery TIM) occur every 50-200 msec

Announcing Buffered Frames



Power Save Non-Polling Operation

- AP will send buffered broadcast and buffered frames for PSNP stations immediately after DTIMs
- Station wakes up just before a DTIM is expected
- DTIM contains a map of all stations with buffered traffic (Coded with Station ID (SID code))
  - When no traffic buffered for that station and no broadcast then station can go back into "Doze" state
  - Otherwise station keeps awake until frame is received
  - "More" bit in Header indicates more traffic buffered
- A station can switch to the active mode to allow transfer of subsequent frames without buffering delay

Power Save Polling Operation

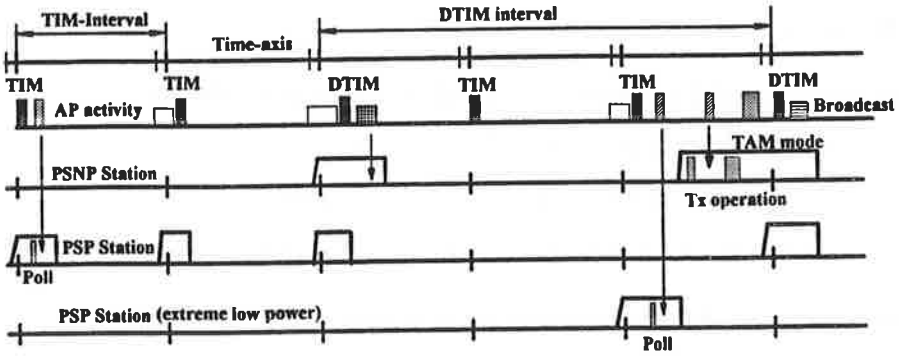
- Each such station independently decides how frequently it must listen for TIMs
- AP will send buffered frames for PSP stations only in response to a Poll frame from that station
  - If nothing buffered, go back to "Doze" state
  - Otherwise station generates a Poll to the AP
- Power conservation/performance tradeoff
- "More" bit indicates additional frames

Power Save Polling Operation (cont'd)

- Sleep interval can dynamically change to anticipate traffic patterns
- PSP stations that want Broadcast service need to listen to every DTIM, and stay awake until Broadcast traffic is transmitted
- Extreme Low Power Stations can choose to wake-up only every n-th TIM (perhaps foregoing broadcast service)
- Stations anticipating traffic can enter a "fast listen" mode (every TIM)

Infrastructure Operation

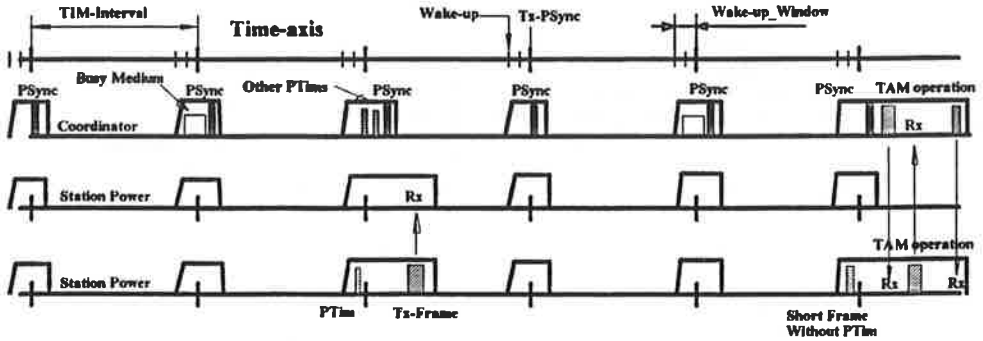
Example: DTIM at every 3 TIM intervals.



Ad-Hoc Power Management

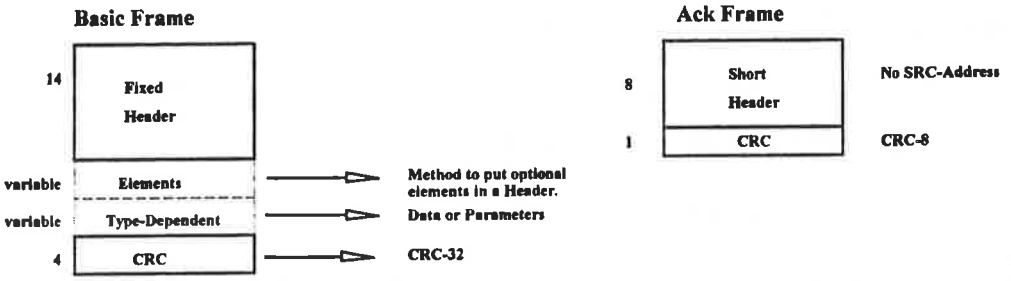
- No central buffering function available
- Timing Coordination function provided by a station, generating a PSync at regular intervals (50-200 msec)
- The PSP mode is not supported
- All stations to be awake in a predefined window before a PSync frame is expected from the Timing Coordinator
- Stations will generate a short announcement frame (PTIM) to the destination in this Awake window
- Stations that received a PTIM will stay awake after the PSync until the actual Data frame arrives

Ad-Hoc Power Management (cont'd)



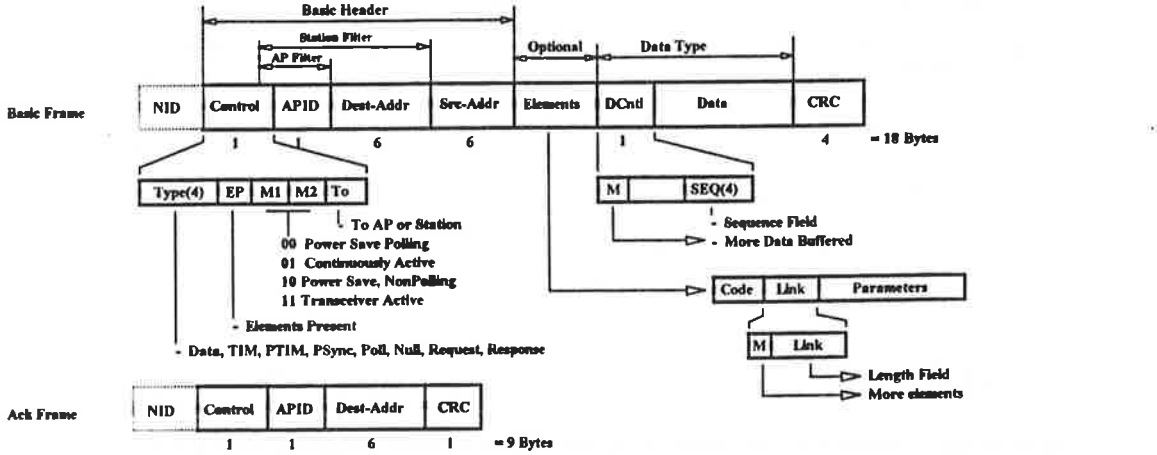
- Short frames can be transmitted without a PTIM
- Stations switch to the TAM mode for performance
- If ad hoc net does not desire power management, system operates as usual under simple CSMA/CA

Frame Formats



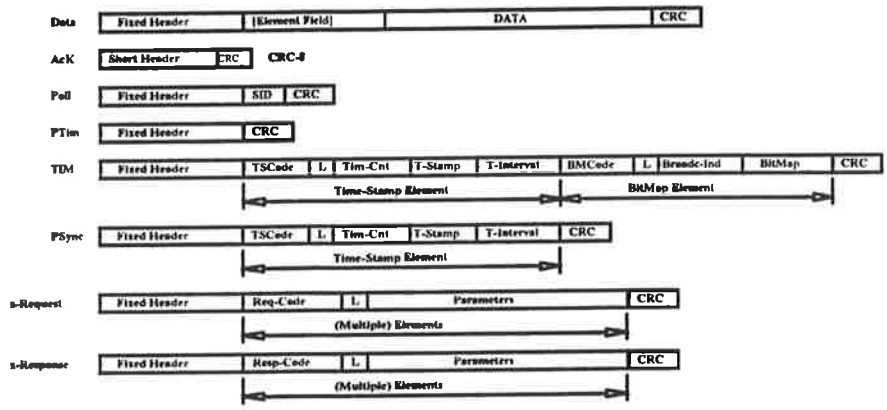
- Two basic formats
- Allow variable Header capability by using Element structure, which allows future expansion of functionality

Frame Header Format



- Power Management bits in every Frame
- Optional Elements in Header can contain TIM's
- Different Frame Types supported

WMAC Frame Type Definitions



Element Fields are expandable and upward compatible

Conclusion

- **BSS Synchronization method is proposed that can be used for multiple purposes:**
  - **Power Management**
  - **Frequency Hop synchronization**
  - **Time Bounded Services & others**
- **Flexible Power Management provisions are presented that are independent of the application**
  - **Multiple Power Save Modes are available**
  - **Allow flexible Speed/Power trade-offs**
  - **Support extreme low power devices**
- **Power Management provisions will be key for mobility**