IEEE 802.11
Wireless Access Method and Physical Specification

Title: **A Distributed Access Protocol proposal supporting Time Bounded Services.**

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Abstract: This paper proposes an extended version of the well known CSMA/CA distributed access protocol (extended with an Ack), and shows its capability to support Time Bounded Services. This paper is focused on the Time Bounded Service characteristics that are possible when using the CSMA/CA access mechanism.
A number of related issue's are addressed at the end of the document.

Introduction:

The concept of CSMA/CA combined with an immediate Ack to allow MAC level recovery was first exposed in document IEEE P802.11-92/51 "A Wireless MAC Protocol Comparison" (ref 1). That contribution roughly explains CSMA/CA, and shows the performance under high load conditions, without and with an added Ack to accomplish MAC level recovery. It shows its excellent throughput efficiency and stability under high load, as well as its inherent medium sharing characteristics that are important in wireless.

Summary:
This document defines a Distributed Coordination Function (DCF), that is based on CSMA/CA + Ack, and references its main characteristics like high efficiency, high load stability and medium sharing capability.
It is an extended CSMA/CA access procedure that allows for Time Bounded Services which in itself is controlled by a Point Coordination Function (PCF) in the AP.

An example is given of the Time Bounded Protocol that is running on top of the CSMA/CA access mechanism, which shows excellent flexibility to support a variety of Time Bounded Services applications. The most interesting aspect is its ability to use reserved but unused Isochronous bandwidth for Asynchronous services, and its variable frame length capabilities. By using the DCF as the basic access mechanism, there is no burden of the Time Bounded Services on Async only MAC implementations.

Basic Wireless Network Architecture

The basic architecture for infrastructure mode of operation is based on a Base Station approach. This means that all traffic will default go via a frame forwarding station to its final destination. The Forwarding function is part of the Distribution System.

The Distribution System connects different BSS's together to one ESS, and provides connectability with existing wired networks.

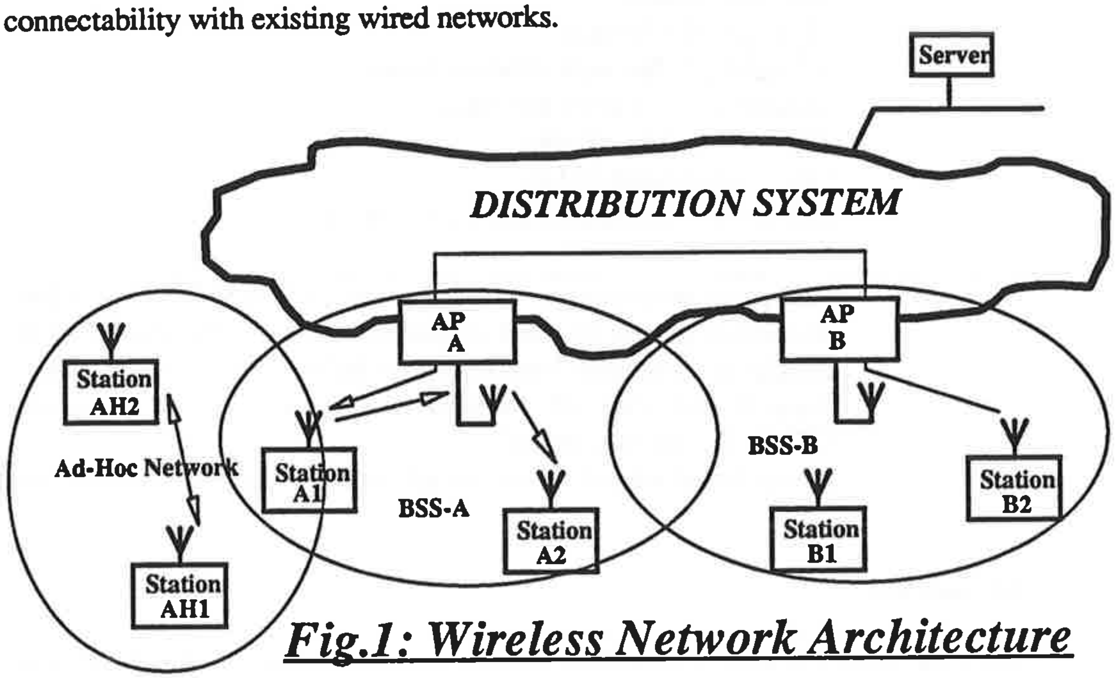

Fig.1: Wireless Network Architecture

General Description of Services Provided

Two different type of services are provided:

- An Asynchronous Connectionless service:
  This service is characterized by a short response time and a high instantaneous throughput which will depend on the load of the medium. It is especially suitable for bursty data traffic.
- A Time-Bounded Connection oriented service (optional):
  This service is characterized by a longer response time, but provides for a steady available bandwidth with very low delay variance. It is especially suitable for applications that require very regular traffic streams like voice. It is limited to the Infrastructure operation mode.

The Time-Bounded Service is only available in those situations that there is sufficient isolation between the different channels used in an ESA. The QoS (Quality of Service) level available depends on the PHY parameters like speed and channel separation.

The service can not be supported when multiple overlapping BSA's (that want Time Bounded Services) are using the same channel.

Asynchronous MAC service

The MAC will support the same service parameters as provided by the IEEE 802.3 MAC which are as follows:

- Destination address is 48 bit.
- Source address is 48 bit.
- A max MSDU length that is PHY dependent.
- No Access priority.

An individual addressing mode is supported with the same Quality of Service (QoS) level as provided by the IEEE 802.3 MAC, with the exception that the channel availability is limited to 99%.
Broadcast and Multicast addressing services are supported but at a lower reliability level, which will depend on the network load, and the interference situation. The QoS level for Broadcast and Multicast services will be subjective to interference, and will depend on the load on the medium.

Time Bounded Service (optional).

This service is optionally available, and can not be supported in every environment, dependent on the PHY.
The Time Bounded Connection oriented service is characterised by the following:

- Framing interval (is delay) in multiples of 20-25 msec. (PHY dependent)
- A 16 bit Connection ID.
- Full or half duplex connection capability.
- Variable frame size per frame interval up to a reserved maximum size.
- Max bandwidth is n*32 Kbps. (depends on speed of the PHY).

A separate Connection Setup Service is specified that allows a station to setup, maintain (Time Bounded re-associate) and disconnect a Time Bounded connection.

This service is dimensioned in particular for Voice applications, thereby providing adequate service for Industrial applications that require Time Bounded Services.

The Quality of Service (QoS) level is dependent on the channel isolation capability in the PHY. Further a recovery mechanism is included that has a limited capability to recover erroneous frames.
Channel availability is limited depending on the PHY, but should be better then 99% as function of space and time.

The minimum_frame_interval is a parameter that should be common within an ESA. The user can control the assigned bandwidth, by requesting a Frame interval (as a multiple of the minimum_frame_interval), and the maximum frame length it wants to use.

The architecture is centralized, with all traffic going via the AP. The AP will control the maximum Time Bounded Bandwidth assignment. This is controlled by a Max_TB_BW parameter. This should be dimensioned such that it allows for at least one maximum size Asynchronous frame to be transmitted in the Framing interval. In addition spare Time Bounded channels should be available to allow some spare capacity for moving stations that already have an active connection, to allow a re-association with an other AP.

Interactions between Asynchronous and Time Bounded.

Asynchronous and Time Bounded services can be mixed on the same channel. The implementation of the Time-Bounded Service is optional, but does not prohibit the coexistence of the two services.
The Asynchronous MAC implementation is not burdened by the coexistence provisions needed to allow a mixed Time Bounded and Asynchronous operation on the same channel.
The response time and throughput of the Asynchronous service will be affected by the active amount of Time Bounded traffic (used Isochronous bandwidth).
The reserved Isochronous bandwidth that is not used by the Time Bounded service will be available for the Asynchronous service. The Isochronous service is not affected by the Asynchronous service network load.

Basic Access Method

Distributed Coordination Function (CSMA/CA)

The basic medium access protocol is based on a distributed Coordination Function (CF) that allows for automatic medium sharing between similar and dissimilar systems based on CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance).
The access method uses a carrier sense mechanism in which the PHY will detect that signal energy in the occupied band is above a threshold, to determine that the Wireless medium is available for that station.
The CSMA/CA protocol is designed to reduce the collision probability between multiple stations accessing a medium, at the point where they would most likely occur. This is just

after the AIFS (Asynchronous Inter Frame Space) period following a frame, because multiple stations could have been waiting for a while for the medium to become available again. So the probability that multiple stations using CSMA would access the medium at exactly the same time is high immediately following a medium busy situation caused by a transmitted frame.
So this is the situation where a random backoff arrangement is needed to resolve medium contention conflicts.

MAC-Level Acknowledgements

MAC level Acknowledgement is an inherent part of the Access protocol. This is achieved by the CSMA/CA + Ack access scheme.
To allow detection of a lost frame (due to interference or collisions), for traffic with a single destination, an Ack is returned by the destination station immediately following a successfully received frame.
The gap between the received frame and the Ack frame is such that it has priority over access of the medium by all other stations which are waiting for the medium to become available.
The Ack is transmitted by the (addressed) receiving station only when the CRC of the received frame is found correct, so it is a positive Acknowledge mechanism.
The lack of a returned Ack can be used by a MAC transmitter to recover from this error by a retransmission of the frame after a random "Retransmission-Backoff".

The CSMA/CA access procedure:

The basic access mechanism is shown in the following timing diagram.

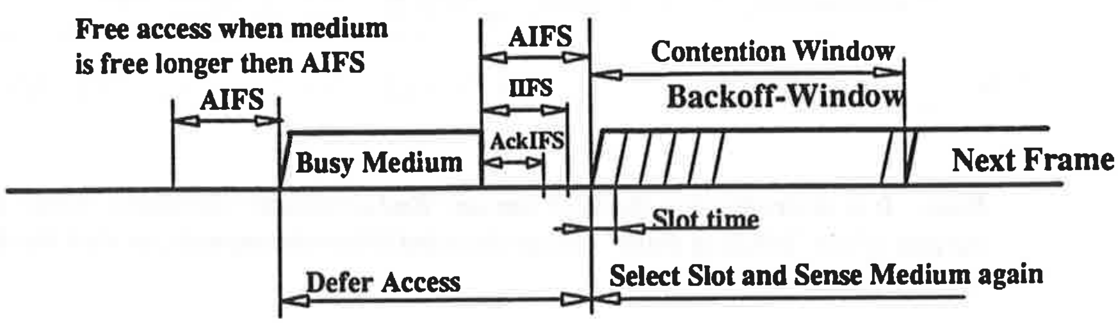

Fig. 2: CSMA/CA Access Methodology with Isochronous capability

The key procedure is that a station that wants to access the medium needs to sense the medium first to assure that a particular minimum silence period (IFS or Inter Frame Space) has elapsed, before the medium is accessed. Three different type of access priorities are distinguished, that use different values for the minimum silence period.

Ack priority:
The Ack is transmitted by a single destination receiver after the AckIFS period has elapsed. This priority level is also used by a station responding to an Isochronous "Down" frame from the AP (frame from AP to Station).

Isochronous Priority:
During an Isochronous burst, the AP will send the next-in-line queued "Down" frame after it finds the medium free for the period IIFS (Isochronous Interframe Space).

Asynchronous Priority:
Asynchronous stations will monitor the medium for at least a time AIFS (Asynchronous Inter Frame Space) of silence. When the medium was found busy, then the WMAC will defer until an AIFS is detected, and then a random Access Backoff procedure is started after which the medium busy status is sensed again.

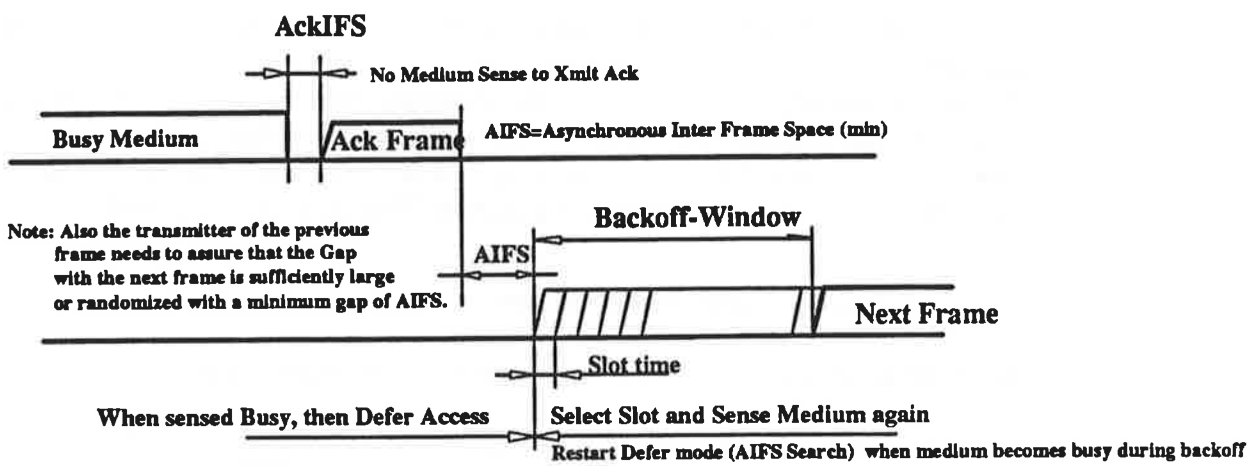

Fig. 3: CSMA/CA + Ack Asynchronous Access Methodology

Note: It is desirable that the PHY has an "End Delimiter" detection means, so that the end of the "Medium Busy" can be detected bitsynchronously, so that the detection delay is minimized.

A station should be able to generate the Ack even when energy is sensed.
The values for AckIFS, IIFS and AIFS are PHY dependent parameters. In addition a High priority AIFS and a low priority AIFS can be specified. The low priority AIFS can be useful for the transmission of certain management frames.

Access Backoff procedure:

Stations that want to access the medium, and find the medium busy, will need to defer until the medium is available (after a AIFS gap is detected), and then generate a random backoff period to resolve contention between multiple stations that have been deferring to the same frame occupying the medium.

Backoff= CW * Rnd() * Slot time

where "Slot Time" = The total propagation delay of :
Transmitter turn-on + (medium propagation delay + "Medium Busy Detect" time) is Carrier Detect response time.
Rnd() = Random function
and CW = A "Contention Window" parameter in slot time intervals.

The Slot Time is dependent on the PHY.
CW is the Contention Window parameter which will have an initial value of CWmin that is loaded every time a new frame is put into the transmit queue to be transmitted. The CW should increase exponentially after every defer, up to a maximum value CWmax. This is done to improve the stability of the access protocol under high load conditions.

When a busy medium is again detected ***in the mean time*** (while in Back-off), then access will be deferred again, searching for a new AIFS silence period, after which a new Backoff calculation is started, and an ACCESS_RETRY_Counter is incremented. When the ACCESS_RETRY_Counter reaches a predetermined RETRY_LIMIT, then the frame will be dropped (or returned). Alternatively an ACCESS_RETRY_LIMIT_Timer can be used, to limit the access delay duration to a fixed maximum.

WMAC Recovery Procedure

When no Ack is received within a predetermined ACK_Window, then the WMAC transmitter needs to generate a random backoff time delay, after which a retransmission attempt can be started to recover from the failure.
This random backoff time can be generated using the same mechanism as used in the Access Retry procedure. The Access_Retry_Counter should be reset, and a RE-TRANSMIT_Counter should be incremented, before a new access attempt is started to retransmit the frame. The retransmission backoff time units may be different from the access retry backoff time units, to better deal with the cause of the lost frame. This can be PHY dependent. For instance Frequency Hopping PHY's may want to retransmit in a different Hop to improve the retransmission success rate.
This process needs to continue until the RE-TRANSMIT_Counter reaches a RE-TRANSMIT_Limit.

Note that the ACCESS_RETRY_LIMIT will typically be in the order of 16-32, while the RE-TRANSMIT_LIMIT is expected to be set to 2-4.

Access Fairness provisions

A station that has just transmitted a frame, and has another frame waiting to transmit, would need to backoff its access also. Otherwise this station would effectively have a much higher access priority, as other stations, who are waiting to gain access to the medium, and were deferring to the frame that was just transmitted.
This can be accomplished by requiring that when after detection of an AIFS period, any pending Asynchronous access should follow the Access Backoff procedure.

CSMA/CA application

The CSMA/CA+Ack is used for all unicast frame transmissions. This includes transfers between a station and an AP in an Infrastructure environment, and between peers in an Ad-Hoc network.
CSMA/CA+Ack is also used for all Broadcast frames that are directed towards the AP. So Broadcast/Multicast frames from station to AP, will all use the CSMA/CA+Ack.

For all Broadcast/Multicast frames directed to Stations, only CSMA/CA is used so without acknowledgement. This includes the Broadcast/Multicast traffic from an AP to a Station, or from Station to Station (for instance in an Ad-Hoc network).
When multiple stations are addressed by the same frame, then the access mechanism will be CSMA/CA. No Ack is generated nor expected when a Broadcast/Multicast frame is transmitted. Consequently there will be no MAC level recovery on Broadcast/Multicast frames. Therefor the reliability of this traffic is subjective to lost frames due to interference or collisions.

Broadcast/Multicast:

Different situations can be distinguished, depending on the Destination of the frame.
In an Infrastructure mode, when a Station transmits a Broadcast/Multicast frame, then there is only one immediate destination station, being the AP. In this situation the used access mechanism will be CSMA/CA+Ack.

Stations will generate Broadcast/Multicast frames, but will also receive their own broadcasts back from the AP. So stations will need to filter incoming Broadcasts and drop any frame that has its own Source address.

Duplicate Detection

Duplicate frames can occur due to the Ack protocol, because the same frame is retransmitted when an Ack was generated, but missed by the transmitting station.

For this purpose a SEQ (Sequence) field is included as part of the Frame Header. This SEQ field is to be maintained on a per destination basis. Time Bounded operation description

Basic MAC model for Time Bounded Services.

The Time Bounded Services are built upon the basic CSMA/CA access method, as shown in the following model.

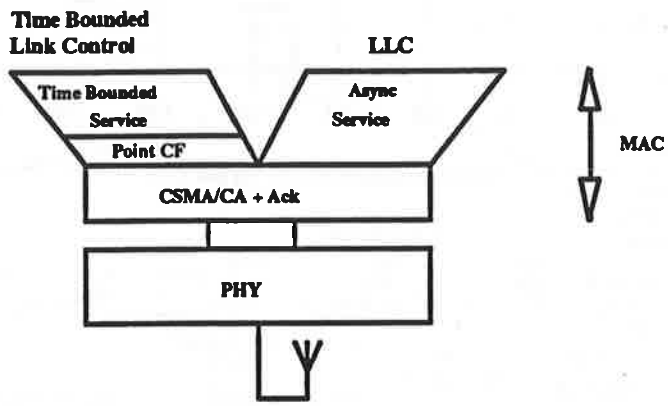

Fig. 4: MAC Service Model

Stations and AP's have the option to implement Time Bounded services. They will only be available when both a station and an AP has those services implemented.
Time Bounded Services are only supported in infrastructure mode, so not directly from station-to-station.

Time Bounded Access Protocol.

Isochronous medium access is controlled by a Point Coordination Function in the AP. The Connection setup service will use the Asynchronous MAC service, and negotiates a connection with the AP to reserve Isochronous bandwidth. This reservation is dimensioned by a "Isochronous Framing Period", combined with a maximum frame size per Isochronous access. The Isochronous Framing Period (IFP) determines the maximum time resolution of the Isochronous system. One Isochronous traffic burst serving all active Isochronous connections will take place per IFP. When a connection is established between an AP and a station, this will be given a 16-bit Connection ID (CID), which is used by a station as an Isochronous address.

The AP will initiate an Isochronous traffic burst at the beginning of each IFP, and a station will only respond when addressed (polling per CID) by the AP.
All Isochronous frames coming from the AP directed to stations that have an active connection are called IDown frames. All Isochronous frames generated by stations are directed to the AP and are called the IUp frames.

It is assumed that all stations within one BSS are synchronised to a timing source running in the AP. Synchronization is done by information in Beacon frames that are send at regular intervals.
The following timing diagram shows the basic operation of the Time Bounded Service implementation. It gives an example for an IFP of 20 msec.

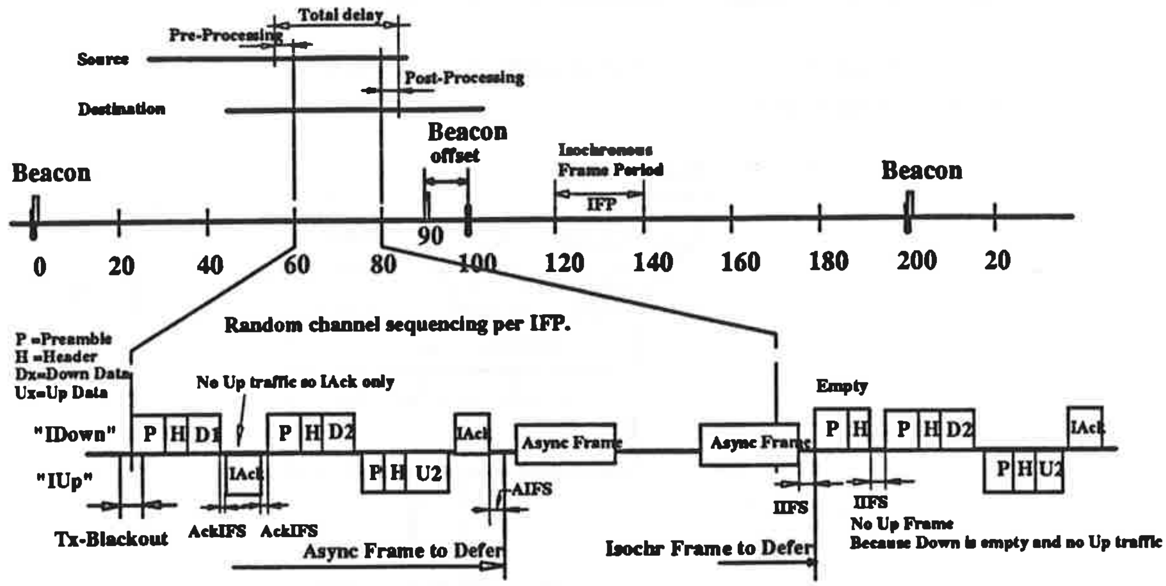

Fig. 5: Isochronous Access Protocol

The following is a brief description of the Isochronous protocol operation of AP and Station.

- The AP is triggered every frame Isochronous Frame Period (IFP) time interval to start the Isochronous traffic burst.
- The AP will hold any pending Asynchronous traffic, and start the Isochronous burst by sending a frame to one of the active Isochronous stations (IDown frame), while deferring for a possible busy medium by an Asynchronous frame.
- Sleeping stations should wake-up sufficient time before the start of an IFP.
- Active Isochronous stations should hold possible Asynchronous traffic, and handle Isochronous Up frames first after an IFP has started.
- There will be a "IDown" frame per individual station that has an assigned connection-ID, also when there is no "IDown" traffic, in which case the data part will be empty.
- When a station is addressed by the "IDown" frame, with a correct CRC, then it will:
  - . Not respond anything when there was neither Down data in the received frame (empty), nor any IUp traffic pending.
  - . Respond with an IAck frame when there was successful IDown data in the frame, while no IUp traffic is pending.
  - . Respond with an IUp frame when there is IUp traffic pending. The IUp frame will contain an Ack/Nack bit to Acknowledge the IDown frame.

- An addressed Station will respond with the IUp or IAck frame after the AckIFS, so has the highest acces priority.
- The next IDown frame (addressed to an other station) will contain an Ack status for the previous IUp frame.
- The last IUp frame is followed by an IAck from the AP.
- An AP will have the next frame ready to transmit, and will do so immediately after the IIFS period. So either the addressed station will send its IUp frame (or IAck), or the AP will send out the next IDown frame for an other station.
- An Asynchronous station that is defering will never see a medium silence of AIFS during this burst, so such a station will defer its access until the end of the Isochronous burst.
- The AP will generate an IDown frame in random order (per IFP) for every connection that is active. So the IDown frame sequence is random. This assures that all active Isochronous stations have on average the same delay until they receive the IDown frame. This allows equal power savings for stations that want to use Power Management. It also allows for equal time to scan for a better channel for reassociation purposes.

The above describes the MAC Isochronous access methodology is dymensioned for a Voice application, with a delay of less then 30 msec and a minimum delay variance.

Recovery Procedures:

The Acknowledgement provisions allow for the detection of lost frames, which can subsequently be recovered. However the recovery should be completed before the end of the IFP. Recovery procedures may be needed to improve the robustness against a remaining level of co-channel interference. The following procedure can be used:

- When the AP does not receive a proper acknowledgement on a non-empty IDown frame, then the IDown frame should be repeated at the end of the Isochronous burst.
- When a station does not receive a IDown frame which is essential a poll function to transmit the IUp frame, then the IUp frame can be send out using Asynchronous access priority, until the IFP is completed.
  Note: This can be achieved by activating the Asynchronous access procedure for the transmission of the IUp packet following the start of the IFP. The access priority could be changed (to Ack-priority) when an addressed Down packet with correct CRC is received. So the recovery will be done automatically when no IDown packet is being received at all.
- When an IUp frame has been send, then the station can verify the proper reception of this frame by the AP, by looking at the next IDown frame in sequence to verify the Acknowledgement status bit.
- When this Ack status is not received then the station can retransmit the IUp frame with Asynchronous priority as above.

The described recovery capability provides for recovery from lost frames due to interference. The main source of interference is dependent on the type of PHY used, and the frequency band used.
The main source is expected to be the co-channel interference. Note that the collision probability with an Asynchronous frame is very low due to the higher access priority. Due to the Point Coordination Function used for the Isochronous traffic, there will be no contention between the stations using the Time Bounded Service. The only possible collision can occur at the beginning of the Isochronous burst initiated by the AP. This will not occur when the AP was defering before generating the burst because in that case it would have the highest priority. It can occur when the medium was idle. To prevent this, a station transmitter could implement a "Tx-Blackout period" as shown in fig 5.

Time Bounded Service implementation characteristics:

The described protocol has the following characteristics:

* Build on distributed access method under control of a Point Coordination function in the AP.
  - Uses CSMA/CA + (Ack) with highest priority.
  - Provides for limited Asynchronous recovery to increase robustness.
  - The connection establishment service uses the asynchronous data services.
* The protocol is dimensioned to support mixed Voice/Data.
  - Video support possible at higher PHY rates.
* Based on 20-25 msec IFP time (using a 2 Mbps PHY).
  - Shorter Framing intervals possible on faster PHY's.
* Support variable frame size on a per IFP basis without added control overhead. The station needs to negotiate the maximum size with the AP.
  - This allows to take full advantage of "Talk Spurt" characteristics of Voice.
  - It allows flexible congestion control for Voice.
  - No dummy data needed to fill unused reserved bandwidth.
* Unused reserved Isochronous Bandwidth is fully available for Asynchronous traffic without any added control overhead.
* Can support different PHY speeds (1-20 Mbps)
* Includes provisions for Power Management and Re-association.
* Minimum burden for Asynchronous Data protocol implementation.

Time Bounded Service capacity

Analyses have been done to evaluate the capacity of this system. The capacity of the system will depend on the PHY speed. The following results are based on a 2 Mbps raw speed of the PHY, using WAVELAN parameters where relevant, and a IFP of 20 msec. A 32 Kbps ADPCM voice source is assumed.

Because of the variable frame size capability, it is easy to deal with a Talkspurt Voice System, that will only generate data as function of a voice activity indicator (use factor of .4 is assumed).
The results are calculated assuming a MAC frame overhead of 15 Bytes and the PHY overhead using the WAVELAN parameters.

The results are as follows:

Voice only:	28 Full Duplex channels (using Talkspurt characteristics)
Voice/Data 576 Bytes:	23 Full Duplex channels (using Talkspurt characteristics)
Voice/Data 1500 Bytes:	18 Full Duplex channels (using Talkspurt characteristics)
Voice/Data 1500 Bytes:	9 Full Duplex channels (assuming 100% load)

Asynchronous Data throughput:	> 75 KByte/sec (assuming max Isochronous load)
Asynchronous Data throughput:	>130 KByte/sec (assuming 9 FDX Talkspurt channels)
Asynchronous Data throughput:	>200 KByte/sec (no Isochronous connection active)

In the above example, (given the 1500 Byte max Asynchronous frame size) the maximum number of connections per cell can best be limited to 9, which still allows for a minimum of approx. 75 KByte of Asynchronous data throughput capacity up to more than 130 KByte throughput capacity when Talkspurt Voice characteristics are taken into account.

The IFP interval and so the absolute MAC-to-MAC delay is dependent on the PHY speed and the maximum frame size of the Asynchronous Data.
The efficiency will increase for longer IFP intervals.

The appendix shows the throughput versus applied load curve for the Asynchronous service as presented in doc IEEE P802.11-92/51(ref 1). It compares the CSMA/CA protocol performance against ALOHA and plain CSMA.
In addition comparisons are given for a protocol extended with an Ack, as is proposed in this paper, and a 4-way LBT protocol as is described by Ken Biba in ref 3, and which is more fully defined in ref 4, currently known as the "WHAT"Protocol.

Conclusion:

A basic distributed access protocol CSMA/CA + Ack is proposed. The main characteristics of this protocol are a high efficiency and stable behaviour under high offered load, that allows efficient medium sharing without added control overhead.
The proposed access protocol includes provisions for Time Bounded Services that have very interresting characteristics. Unused but reserved Isochronous bandwidth becomes directly available for the Asynchronous data service. Furthermore the variable frame size per Isochronous Frame Period (IFP) is ideal to implement a Voice system based on Voice activity, and congestion control, without any additional control overhead.

By using the DCF as the basic access mechanism, there is no burden of the Time Bounded Services on Async only MAC implementations.

Issue's Addressed:

10.1 What Coordination Function (CF) will be specified in the standard.

A Distributed coordination function (CF)

A Distributed Coordination Function should be specified as the primary mode of operation. A DCF based on CSMA/CA + Ack as proposed in this document has good medium sharing characteristics without added control overhead. The throughput efficiency is high and stable for high loads. It is well suited for Ad-Hoc operation, and allows overlap of infrastructure and Ad-Hoc, even on the same channel. It does fully support single channel PHY's.

A Point Coordination Function (PCF) can be built on top of the proposed CSMA/CA access method, allowing full coexistence and efficient sharing between Asynchronous and Time Bounded Services. Reserved but unused Isochronous bandwidth is fully available for the Asynchronous service, without any control overhead. The proposed Time Bounded Service implementation using the CSMA/CA access method with priority does not burden the implementation of an Asynchronous Service only MAC.

10.2 Events to switch between multiple CF's.

There are no multiple CFs needed as basic access method. A Point Coordination Function (PCF) can be used as described for the Time Bounded Service, but it is built on top of the DCF. So the DCF is the basic CF. Therefore Switching is not applicable. This also covers the issue'd 10.2-A and 10.2-B.

10.3 Issue's surrounding PCF and DCF.

By using DCF as the basic CF, with a PCF on top of that for Time Bounded, there is no issue related to overlap of Ad-Hoc and infrastructure networks. For the same reason there is no issue for the MAC to operate on a single channel PHY, because of the medium sharing characteristics of the DCF.

15.6 Partition of capacity Time-Bounded and Asynchronous service.

The AP should partition the capacity mix. Given an Isochronous framing Period (IFP) the bandwidth per Isochronous connection is defined by a maximum frame size. This is the maximum that a station can occupy per IFP, but a variable length up to the reserved maximum is possible. An AP should limit the maximum assigned total Isochronous bandwidth such that at least one maximum size Asynchronous frame does still fit in the IFP period.

In addition an AP should reserve some spare capacity to allow stations with existing connections to re-associate with the AP, so that the connection can be maintained.
New connection setups can be refused when the system is already using the reserved (for re-association) capacity.

15.7 What is the common Service, Async or Time Bounded.

Asynchronous Data service is the common service. Time Bounded is optional available, and does not need to be supported by every station. The use of the Time Bounded Service is restricted to environments and PHY's that allow for sufficient isolation between BSS's to limit co-channel interference.
The Asynchronous service can be used to provide connection setup services to establish a Time Bounded connection.

15.8 Do All Stations and Infrastructure support Time Bounded Services.

No, Time Bounded Services are only supported in Infrastructure networks, and will need an AP. Not all stations within an ESA with infratructure need to support Time Bounded Services. Its service is optional, and dependent on the PHY isolation.
When Time Bounded service is supported within an ESA, then all AP's covering the area of operation need to support Time Bounded Services to assure continuous operation, but there can be a mix of stations that do and do not support Time Bounded Services.

15.9 MAC ability to service Data Voice and Video.

Data service is always available.
The MAC can support different Time bounded service levels, depending on the PHY speed and characteristics. The MAC should support a range of PHY speeds. The Time Bounded Service levels can distinguish between Voice and Video, or any lower multiple of the primary Time Bounded Service (as a integer multiple of the IFP).

15.11 Classes of Time Bounded Services to specify.

A basic Voice service level (class) would be default provided (when supported). Due to the variable frame size flexibility of the methodology described in this paper, this will automatically serve all lower ranges, although they can be specified as separate levels (using a longer IFP, being an integer multiple of the basic IFP).
A separate Video class may be needed.

19.5 Does a recovery mechanism have to be in the MAC.

Yes: Since the wireless medium is interference limited rather than noise limited, MAC level recovery is needed to restore the delivery reliability level to that defined by 802. This can not be accomplished by PHY level recovery.
Note that MAC level recovery is not practicle for Broadcast/Multicast frames, which will result in a lower delivery reliability then specified in 802.

19.10 Stability under heavy load.

The CSMA/CA protocol is demonstrated to be stable under high load. Reference doc IEEE P802.11-92/51 for simulation results.

26.1 The need to address priority in the MAC.

Different access priority levels have been identified in the CSMA/CA+Ack proposal presented in this document. The different priority levels are only used for inter-MAC operation, and is not available to the user/LLC. If needed, then different priority levels can be made available.

References:

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