TIME BASED SERVICES - QOS REQUIREMENTS ON A WIRELESS LAN

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At least four major users of Time Based Services (TBS) identified by IEEE 802.11 Surveys of User Requirements:

SP - Speech

VD - Video

IA - Industrial automation - monitoring and control

MM - Multi-media - see Tim Kwok's papers

UNDERLYING DATA TRANSFER REQUIREMENTS

TB services all provide for "faithful reconstruction"
and possibly alteration by feedback
of NATURAL PROCESSES

SP=speech,
VD=video - freeze frame or live-action,
B&W or color, &
audio,
IA=chemical reactions,
robotic & machine motions,
water & sewer systems
"transporters"
etc.)
MM= - see Tim Kwok's papers

ALL NATURAL PROCESSES

* Produce complex frequency patterns (fundamental freq. & harmonics)

* Frequencies produced are related to:
  - Mass
  - Damping or "Loss"
  - Forcing Function - less important

"FAITHFULLY" RECONSTRUCTING *ANY* NATURAL PROCESS

R1. Need to transmit/reproduce all "significant" frequencies

Two approaches
- Ideal (Nyquist) = 2 samples of highest harmonic = Voice Codec
- Industrial = 5-10 samples of fundamental freq.

R2. Need "minimal" variable phase shift (JITTER) between samples
- Industrial = 10% - 20% of sample period

"FAITHFULLY" RECONSTRUCTING SIGNALS THAT ARE SUBJECT TO FEEDBACK eg. "REAL TIME DATA", eg. Speech, Industrial Control

R3. Jitter can not be mathematically compensated

R4. Average & Max. Delay as well as Jitter must be bounded to less than ~ 25% of the fundamental freq.

QUALITY OF SERVICES NEEDED FOR TIME BASED SERVICES

The general form (Model) of Quality of Services (QoS) needed for TBS (SP, VD & IA, at least) is quite similiar.

* The specific (numerical) requirements are determined by:
    1. the characteristics of the underlying natural process,
    2. the "reconstruction faithfulness" required by the ultimate user (SP=human, VD=human, IA=control computer & "process"),
    3. the sophistication of the sampling, transmission & reconstruction equipment.

SPECIFIC CHARACTERISTICS SPEECH (SP) & VIDEO (VD)

* Speech Encoding/Reconstruction formats and Video formats in major geographic areas (North America= NTSC) are well known processes, with standardized data transmission requirements, eg. underlying Data Transfer Requirements.

Qdt SP = ~8 Khz at 8 bit quantitization
= 64Kbs (ISDN Voice)

Qdt VD Broadcast (non compressed)
= ~30 or 60 frames/sec = 5 Mhz (NTSC)
= 50 ffames/sec (PAL)

Qdt VD Slow Scan (non compressed)
= ~0.2 frames/sec = ~20 Khz

* Qdt VD illustrates the impact of the ultimate user's requirements on the required bandwidth and QoS.

SPECIFIC CHARACTERISTICS INDUSTRIAL AUTOMATION (IA)

* Industrial processes have widely varying natural periods
  = 10+Hz for many mechanical motions to
  = 1/25,000 Hz for some liquid tank filling processes.

* In addition, current sampled data control algorithms do not allow for local buffering at the data source.

NOTE: the number of industrial processes precludes exhaustive study as was done for speech compression.

Qdt IA Mechanical = 100 samples/sec as 40 bits (IEEE 754 + Status)
= 4,000 Hz

Qdt IA Liquid = 0.1 samples/sec as 40 bits
= 4 Hz

NOTE: These "ultimate user" data rates given above do not account for the overhead of WLAN operation.

* These requirements can be further expanded and clarified in terms that are directly meaningful to WLAN operation:

TBS QOS MODEL FOR WLANS

Fundamental TBS QOS requirement is

Q1. Assured Bandwidth for transfer of variable values via the WLAN.

Q1a. enough samples of the natural signal must be sampled and conveyed.
IA= roughly 5-10 samples/cycle of fundamental frequency
SP= 2 samples of highest significant harmonic (4KHz)

Q1b. If local buffering is allowed
by the reconstruction algorithm and ultimate user (eg. a non-real-time usage), then
rate of transmission opportunities can be reduced proportionately.

Q1c. If compression is allowed by the reconstruction algorithm and ultimate user,

then the

transmitted data rate can be reduced proportionately.

POSSIBLE SPECIFIC *DATA RATE (BANDWIDTH)*- TBS QOS PARAMATERS

The Data Rate TBS QOS requirement is:

Q1 SP = 64 Kbs

Q1 VD Broadcast <= 5 Mbs

This service (un-compressed, Broadcast quality video) is obviously outside the scope of WLAN.

It is provided by dedicated bandwidth on Broadband LANs along with 802.3 & and 802.4 in separate frequency bands.

Q1 VD Slow Scan >= 160 Kbs

Q1 IA Mechanical <= 160 Kbs

Q1 IA Tank Level >= 0.160 Kbs

POSSIBLE SPECIFIC *CYCLIC* TBS QOS PARAMATERS

The second TBS QOS requirement is:

Q2. Regular (Cyclic) Media Access for timely reconstruction of or control actions on the variable.

Q2a. The samples of the variable must be conveyed at regular, cyclic periods that allow "faithful, timely reconstruction.

Q2 SP = Transmit opportunities every ~125 us

Q2 VD Slow Scan = Transmit opportunities <= every 2*N sec
to allow for limited data frame size & complete video frames each 2 secs. N=

data frames per video frame

Q2 IA Mechanical = Transmit opportunities >= every 10 ms

Q2 IA TankLevel = Transmit opportunities <= every 10 sec

POSSIBLE SPECIFIC *CYCLIC* TBS QOS PARAMATERS for REAL TIME DATA

The third TBS QOS requirement is:

Q3. Acceptable levels of Jitter between transmission opportunities to allow "faithful" reconstruction or control action.

This requirement only applies when the reconstructed variable will be used in "real time".

Jitter allowed is proportional to the user's sense of time.

Q3a. Normally jitter can be about 20% of specified time between Transmit opportunities.

Q3 SP for further study

Q3VD Slow Scan - video frame jitter <= 0.2 sec

Q3 IA Mechanical >= 2 ms

Q3 IA Tank Level <= 1 sec

Q3 IA ?? = ??

POSSIBLE SPECIFIC *DELAY* TBS QOS PARAMATERS for REAL TIME DATA

The fourth TBS QOS requirement is:

Q4. Discard of "Late Data"

None of the reconstruction or control algorithms for TBS are designed to cope with data that

arrive out of order or
significantly beyond the designed time window (the transmission interval).

Q4a This data may be discarded by the MAC

POSSIBLE SPECIFIC *EFFICIENCY* TBS QOS PARAMATERS for REAL TIME DATA

The fifth TBS QOS requirement is:

Q5. Dead spaces - Unused bandwidth

Q5SP& VD - Speech and compressed video make have periods of very low traffic, due to pauses in speech or action.

Q5 IA - Due to simpler sampling algorithms, this does not typically happen in industrial systems.

POSSIBLE SPECIFIC *CALL CONTROL* TBS QOS PARAMATERS ~~for REAL TIME DATA~~

The sixth TBS QOS requirement is:

Q6. Call Duration

Q6 SP 5 sec to M hrs
M = "longest "reasonable call duration

Q6 VD 10 min to infinite (security monitor)

Q6 IA 4 hrs to infinite

CONCLUSIONS

1. It is obvious that speech, video and industrial control share the same general model of TBS QoS, but with divergent parameters.

2. The mechanisms needed to support speech will also support Industrial Automation

3. The 802.11 WG should take care to provide TBS in a way that is useful for all the Time Based Services, when adequate bandwidth is available.

3a. When adaequate bandwidth is not available, certain TBS may not be possible.

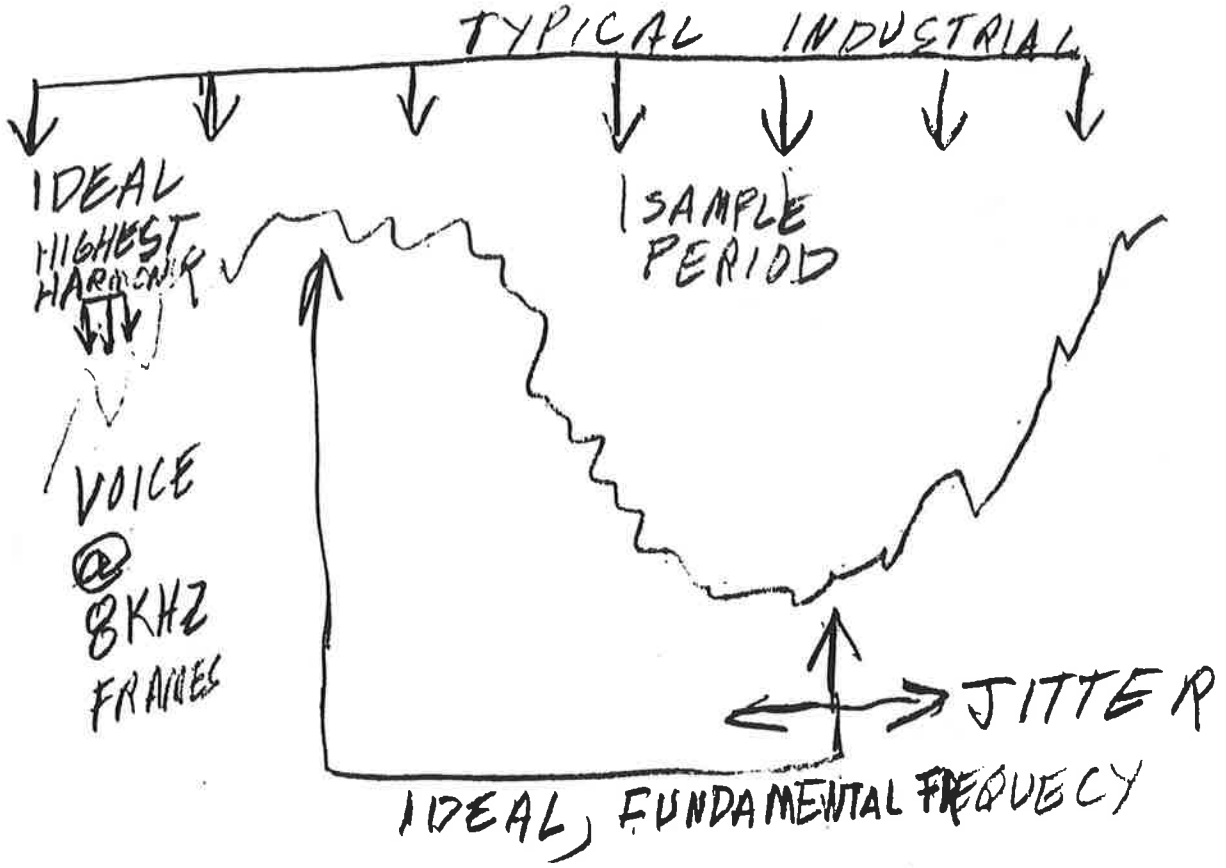
NOTE: The author requests contributions on the numerical QoS requirements for speech, video and multi-media from WG members.

BIG PICTURE
MICROSCOPIC PICTURE

TANK
LEVEL
VALVE
PUMP

VOCAL CORDS
SOUND WAVES
(AIR PRESSURE)

DISPLACEMENT
PILOT
SPRING



SAMPLING & RECONSRUCTING A SIGNAL