Isochronous Resource Reservation with the Probability based Admission

March 14, 2007

Orlando, Florida

IEEE 802.1 AVB TG

Seong-Soon Joo, ETRI

To be certified as AV-Ethernet compliant

- Specifications on AV-Ethernet compliant
  - achieve less than 2 ms latency through up to 7 hops
  - guarantee at least 25% bandwidth for non-AV services
    - on unit time: 125us for 100Mbps link and 1ms for 1G link

- Validation on AV-Ethernet compliant
  - Check completion of protocol implement conformation statement of IEEE 802.1AS, 1at, (1av)
  - Check Policing, shaping, pacing function

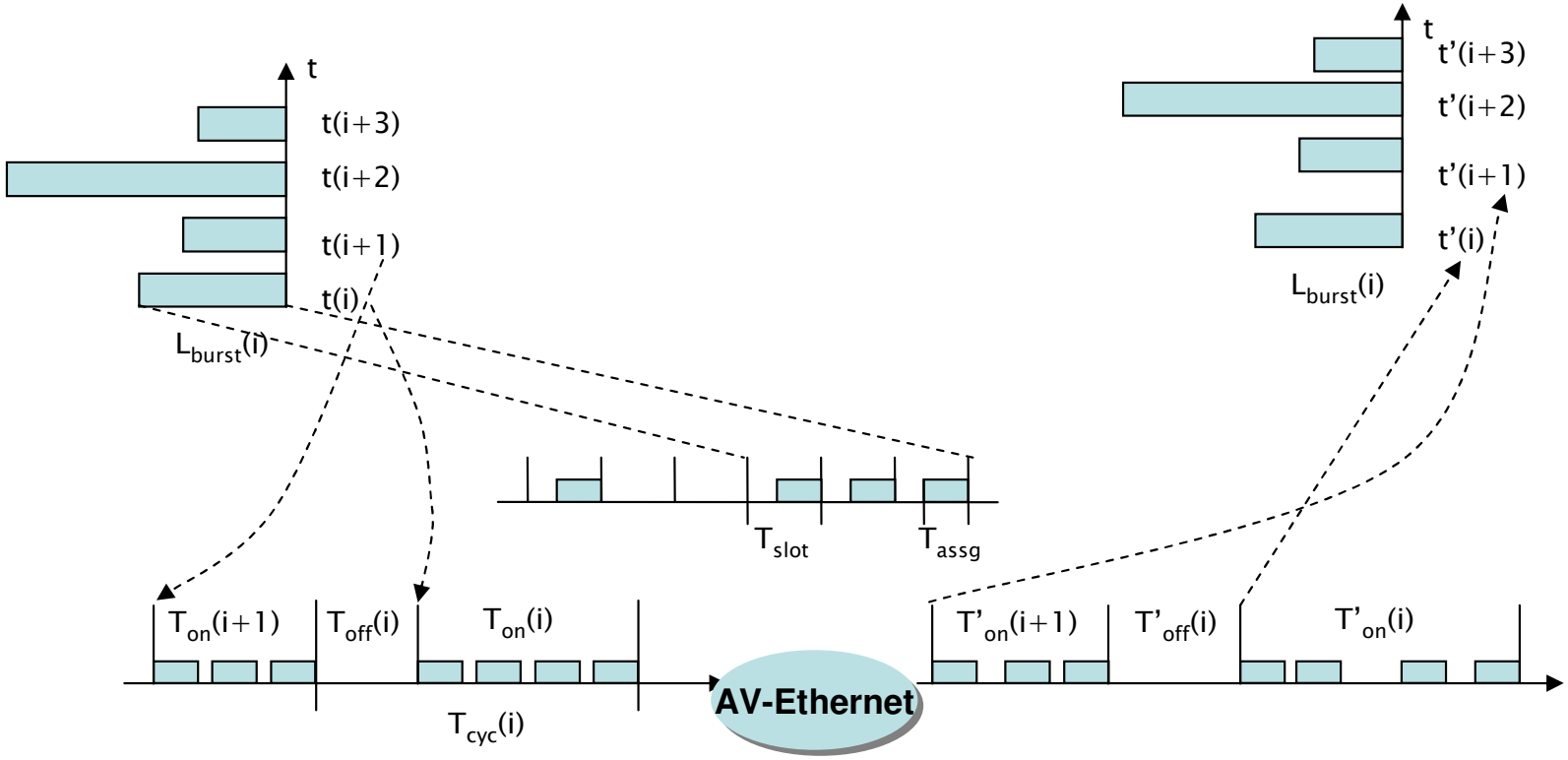
- How to validate forwarding functions ?
  - Measure the performance with the reference topology, reference traffics, and test scripts
  - Or invent test scenario to verify the specific actions on policing, shaping, pacing function

  - In any case, we have the concrete specifications for developing the IEEE 801.1av draft ?

How to use the new tool efficiently ?

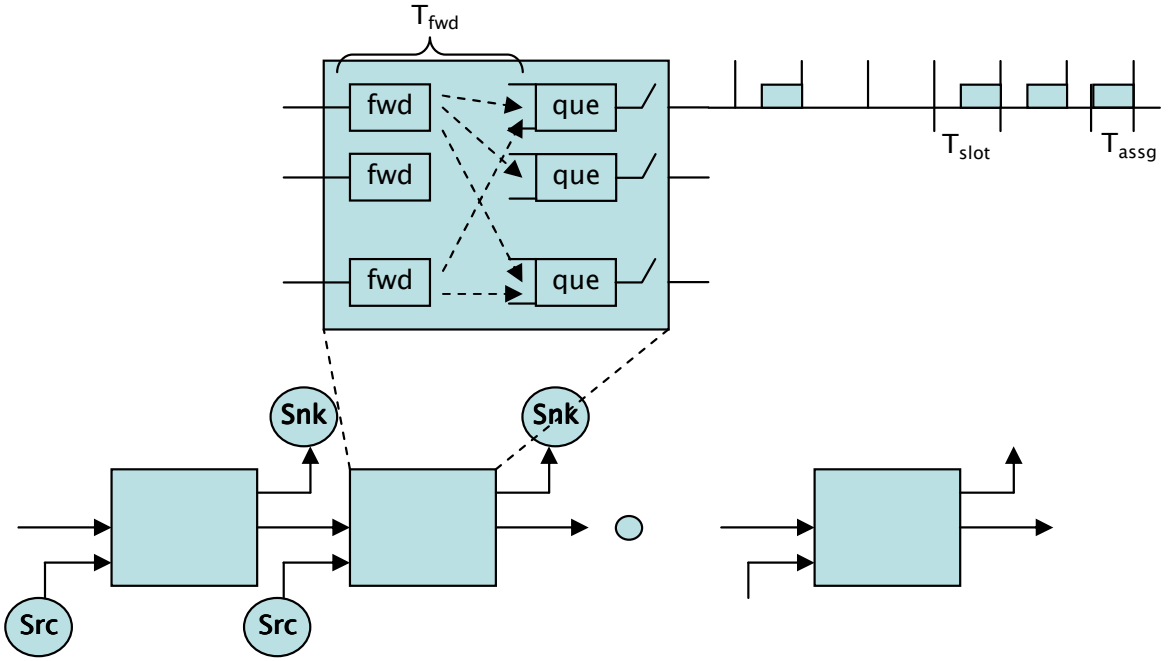
- New tool for resource reservation and forwarding
  - Reserve resources and de-queuing frames in sense of time manner
    - Metering whatever per stream or per port for the unit time
  - Needs new concepts on policing or shaping in AVB
  - Enough just with forwarding functions for providing the goal of .1av ?
    - bounded latency and delivery variations, and loss-sensitive real-time audio video data transmission
- Guaranteeing quality of service in AV-Ethernet compliant
  - Determines whether a new connection can be accepted or not
    - A new connection does not deteriorate QoS of all the existing connections
  - How to check newly admitted session will not effect on current sessions' end-to-end delay, variations, loss in frame forwarding at AVB
  - Challenging problem, especially when all connections are VBR traffics
    - It will be easy task when adopts a deterministic CAC, which admits a connection if the sum of connections' peak rate is less than link capacity.
  - Without defining guidelines on admission for AV-Ethernet compliant bridge, it will be difficult to have uniform quality just with implementing forwarding functions whatever they are.

AV-Ethernet for VBR Traffics



- Length of application datum will be varying one by one
  - Varying length and consecutive appearance can be modeled as a statistical on-off flow
- At the *i-th* moment, a service datum, which has length *Lburst(i),*
  - fragmented to transmit on a link and occupies a link for *Ton(i)* time
  - the *Toff(i)* hangs till the next data generation
  - in case of the VBR service, the *Ton(i)* and *Toff(i)* can look upon as the time process of the random variables changed from time to time in extreme case
- In AV-Ethernet,
  - the assigned transmission time per metered unit time (slot) for a stream can be calculated as
    - $Tassg = Tslot * \Sigma_i Tburst(i)/\Sigma_i (Tburst(i)+Toff(i))$
  - end-to-end delay and difference in consecutive appearance

Isochronous frame forwarding in the AVB (Metered frame forwarding)



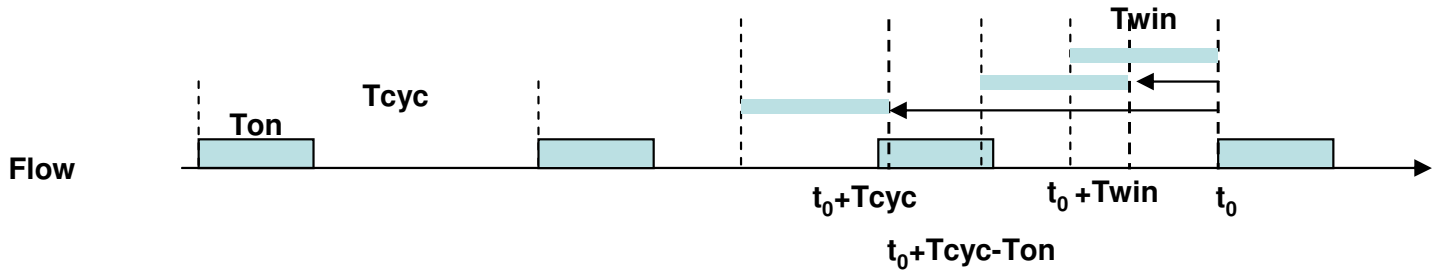
- In AV-Ethernet,
  - a packet has experience in delay, range of *Tfwd + (0 ~ Tslot-Tassg)* at every node
- If all flows existing in the network are CBR traffics, admitted within available link capacity
  - average delay on an end-to-end path with *n-hops* will be *Tslot+n*(Tfwd+(Tslot-Tassg)/2)*
- When all flows are VBR traffics,
  - range of end-to-end transport delay for an application service datum will be calculated as
    - *Tslot * Tburst/Tassg + n*Tfwd + (0 ~ n*(Tslot-Tassg))*
- If all traffics are VBR, users will have experience in delay jitter
  - range from *0* to Σ_n *Pcgst_i(Tburst,Tassg)*(Tslot-Tassg)*
    - where *Pcgst_i(Tburst,Tassg)* is the congestion probability at the *i-th* hop occurred by adding a flow with *(Tburst, Tassg)* to current served flows on the end-to-end path

Connection Admission in AV-Ethernet (I)

- In AV-Ethernet, admission of a new connection is determined
  - whether the variance of delay range in *(0 ~ Σ_n Pcgst_i(Tburst, Tassg)*(Tslot-Tassg))* is over
  - the limit for satisfying the QoS of all the connections or not

- To solve CAC problem
  - *Pcgst_i(Tburst,Tassg)* has to be described in terms of *Ton* and *Tcyc*.
  - how long a link is reserved by the flows with a probability

- To estimate *Pcgst_i(Tburst, Tassg)*
  - the probability that a flow occupies longer than *Tcgst* time within *Twin* window,
    - *Pcgst(k) (Tcgst|Twin)*
  - and the expected duration of occupying a link with C(k) on *Twin* is calculated as
    - *Tcgst * Pcgst(k) (Tcgst|Twin) * Twin*



Pr(exist a flow for *Tcgst* times within *Twin* durations from arbitrary starting points) = Pr $(X \geq Tcgst)$

$$Tcyc \geq Twin \geq Ton \geq Tcgst : \Pr(X \geq Tcgst) = \left(2(Ton - Tcgst) + 1\right) / Tcyc$$

$$Tcyc \geq Ton \geq Twin \geq Tcgst : \Pr(X \geq Tcgst) = \left(2(Twin - Tcgst) + 1 + Ton - Twin\right) / Tcyc$$

$$Tcyc \geq Twin \geq Tcgst \rangle Ton : \Pr(X \geq Tcgst) = 0$$

$$Twin \geq Tcyc \geq Tcgst \geq Ton : \Pr(X \geq Tcgst) = \left(Ton * Twin / Tcyc - Tcgst + 1\right) / Twin$$

$$Twin \geq Tcyc \geq Ton \rangle Tcgst : \Pr(X \geq Tcgst) = 1$$

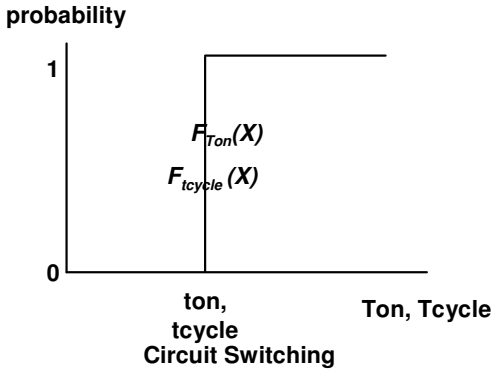
Connection Admission in AV-Ethernet (II)

- Step 1: calculate or estimate the required bandwidth in a slot for a new connection, which has class *k*. *Tassg(k)*
- Step 2: calculate available bandwidth at each i-th node on the end-to-end path by $Tslot - \Sigma_{i,k}^{K,K} l(i) * Tassg(k)$ and keep this value as *Tcgst_i*
- Step 3: calculate congestion probability at each *i-th* node on the end-to-end path, *Pcgst_i*
- Step 4: calculate variance of delay range in *(0 ~ Pcgst_i(k) *(Tslot-Tassg))* and check whether delay range is over the limit for satisfying the QoS of service class *k*
- Step 5: repeat procedure from step 2 to step 4 and accept a new connection, if delay range is not over the limit at every nodes on end-to-end path

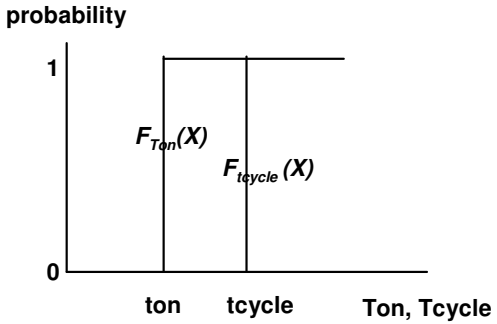
Quality of Experience for A/V Service

- For comfortable communication in users' perspective
  - required for satisfying users' quality of experience
  - it is related to but differs from Quality of Service
  - Quality of Experience is a subjective measure from user's perspective of the overall value of service provided.
- A limited form of QoE measurement process
  - Mean Opinion Score (MOS) used for assessing the quality of telephone connections
  - No multi-media version of the MOS process seems yet to have been developed
- For the provider, it needs a way to measure the customers' perception
  - how good of a job the service provider is doing delivering the service.
  - even though Quality of Experience is a subjective measure of a customer's experiences
  - it can be achieved by measuring the value of which affects mostly users' experience
- One of the measurable values in view of provider
  - the end-to-end delay for transmitting a whole application datum generated at each time
  - the difference in consecutive appearance of application data at the receiver end

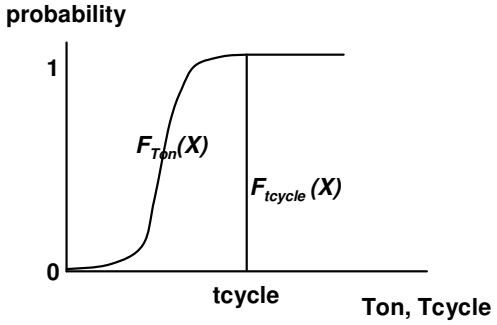
QoE Measurements for VBR Traffics



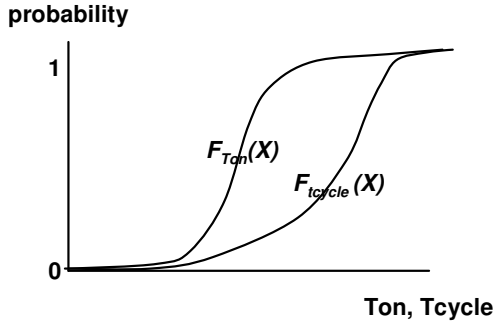
Circuit Switching



CBR in Packet Switching



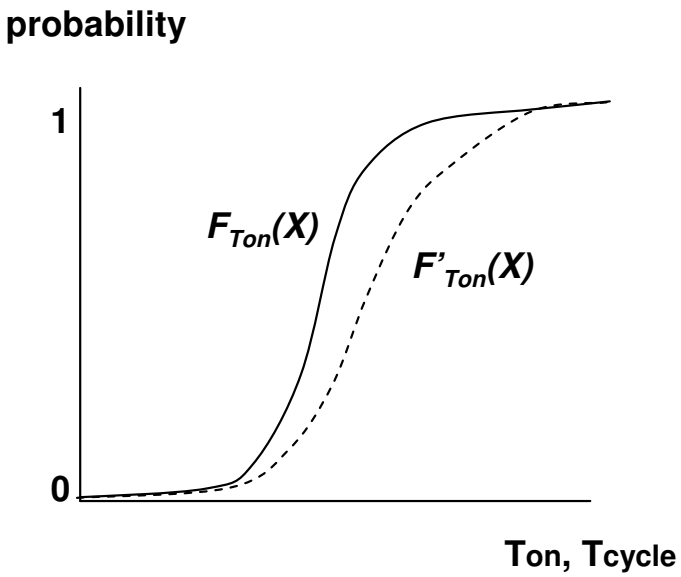
VBR-rt in Packet Switching



VBR-nrt in Packet Switching

- Traffic behavior of an application service can be specified by the statistical characteristics of *Ton(i)* and inter-generation time of application service datum, *Tcyc(i)*
  - statistical property of traffic flow described in terms of the length distribution on *Tcyc* and *Ton*
- *CDF* of *Ton* and *CDF* of *Tcyc* have various shapes according to the application service
  - A service with small variance on *Ton(i)* and *Tcyc(i)* will show more constant bit rate traffic behavior
  - In case of the circuit switching, CDF of *Ton(i) & Tcyc(i)* are equal
- With these observations, QoE can be measured by
  - QoE measured by end-to-end delay and difference in consecutive appearance
  - how much original statistical property of the traffic is distorted at the receiver end

Distortion Ratio of Service (DRS) in delay and jitter



DRS in Delay $= \int F'on(X)dx / \int Fon(X)dx$

DRS in Jitter $= \int F'cyc(X)dx / \int Fcyc(X)dx$

- For measuring the QoE, in terms of network provider, we propose a measure
  - the Distortion Ratio of Service datum (DRS) in delay and jitter
  - DRS in delay is defined as the ratio of integration of *Fon(i)* and *F'on(i)*
  - DRS in jitter is defined as the ratio of integration of *Fcyc(i)* and *F'cyc(i)*
- Closer DRS is to 1, Better QoE users get

Summary

- Consider the problem of guaranteeing QoE for the AV-Ethernet compliant bridge
- Suggest on-off flow model and a new measure of QoE, the Distortion Ratio of Service (DRS)
- A connection admission control algorithm based on congestion probability calculated with on-off flows' statistical property
- We have the concrete specifications for developing the IEEE 801.1av draft ?

Questions or Comments ?

ssjoo@etri.re.kr