Quality-of-Service Provisioning System for Multimedia Transmission in IEEE 802.11 Wireless LANs

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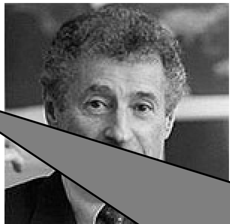
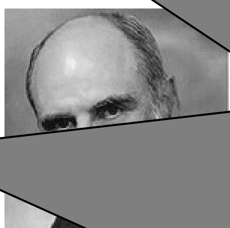
The next wave of the Internet

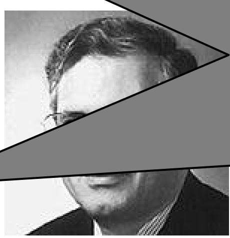
The Net's founders predict its future:



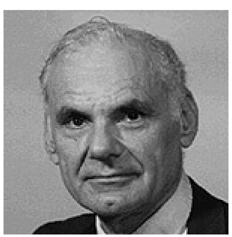
"Nomadic computing, providing access wh you're on the road so that the Internet services you see when you're place else are no different than what you ha ck in your of --Leonard Kleinrock



u have a question, Net and pull Cerf



te speed e're going to see increa --Robert Kahn



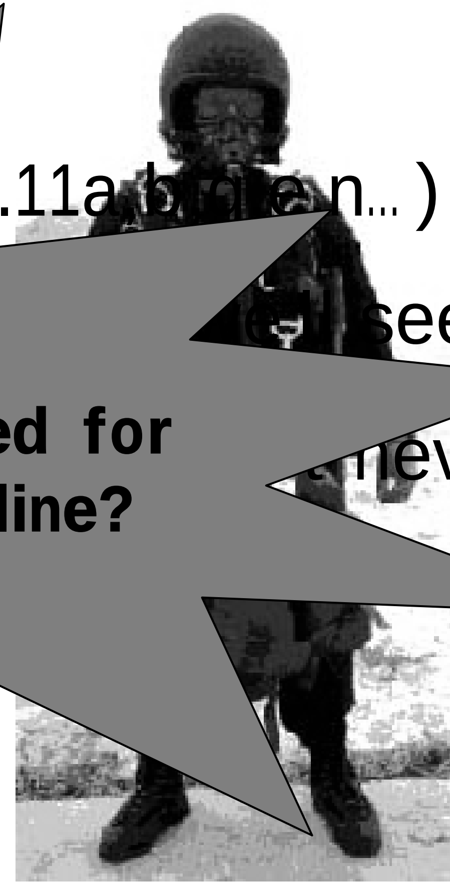
"Th nternet w e the p network for th orld's telecom traffic. Voice and will transfe er to it in the next five to 10 years. Clearly, you going to have vid o on demand, radio or TV, that can have millions of di erent sources or special subjects that (small numbers) care about." --Lawrence Roberts

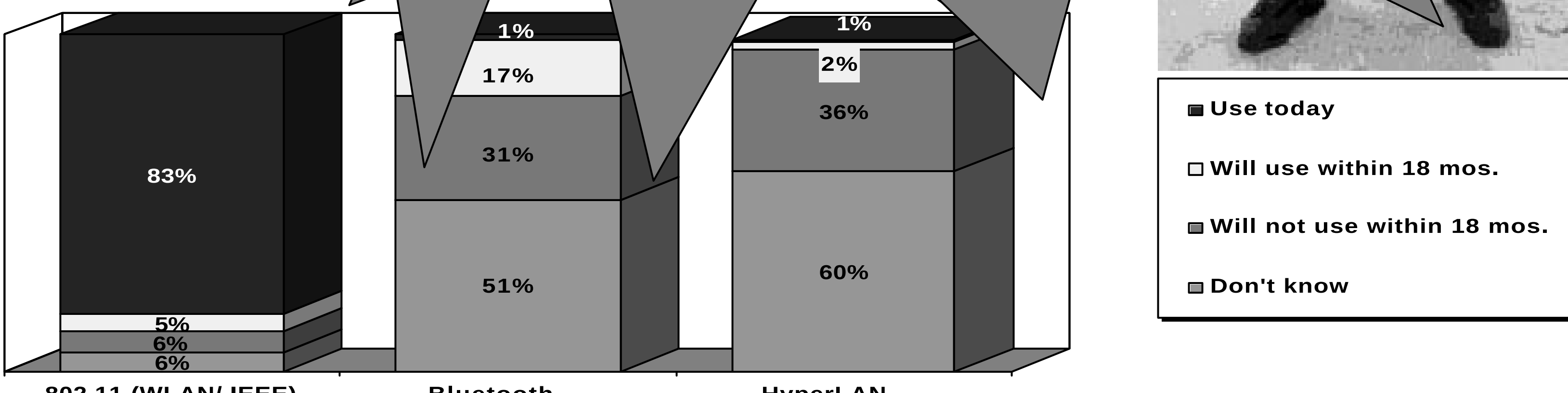
Towards Multimedia Oriented Mobile Systems and providing "Anytime Anywhere Anyform" Information Systems

Status of specified wireless networking technologies

- 802.1 … ke … rowin … 2.11a,b … n…)
- Blue … see
- … never
- t…

What applications are suited for current status and time line?

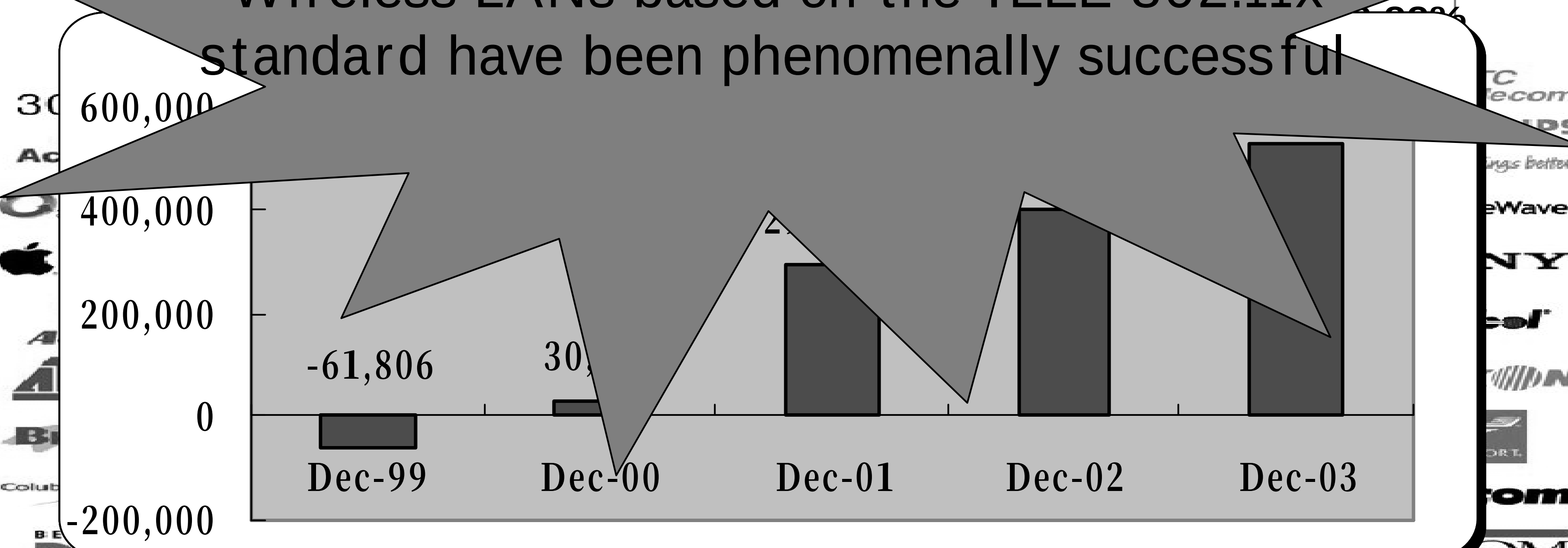




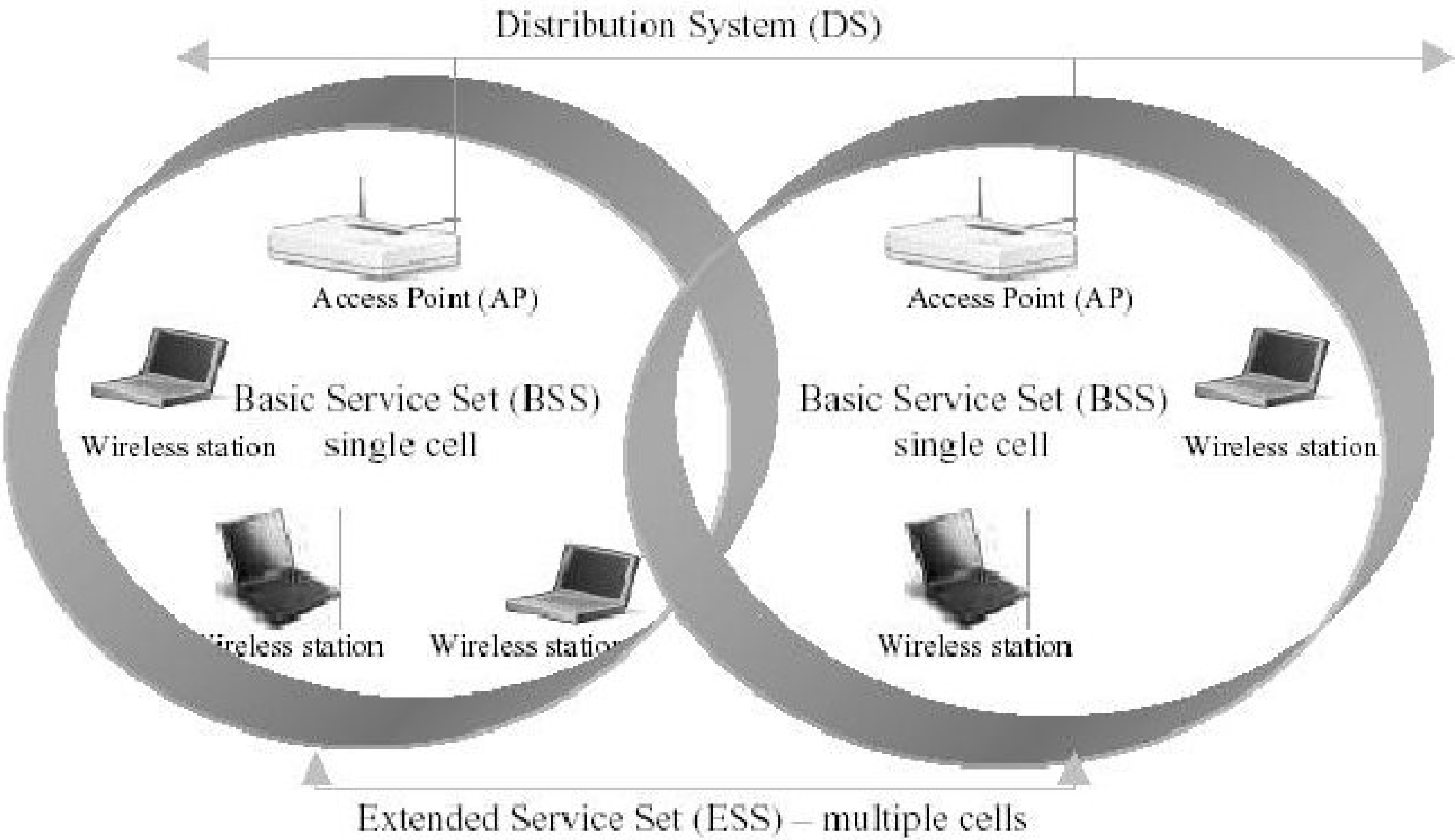
IEEE 802.11 Market

- Emergence of the Wireless ISP
- Currently, 71,500 hotspots deployed wo dwide, expected to growth to around 47 000 by 2007 (cati Group)
- l unched its ireless in March 2003. The nex tion of 2005 and Napa in

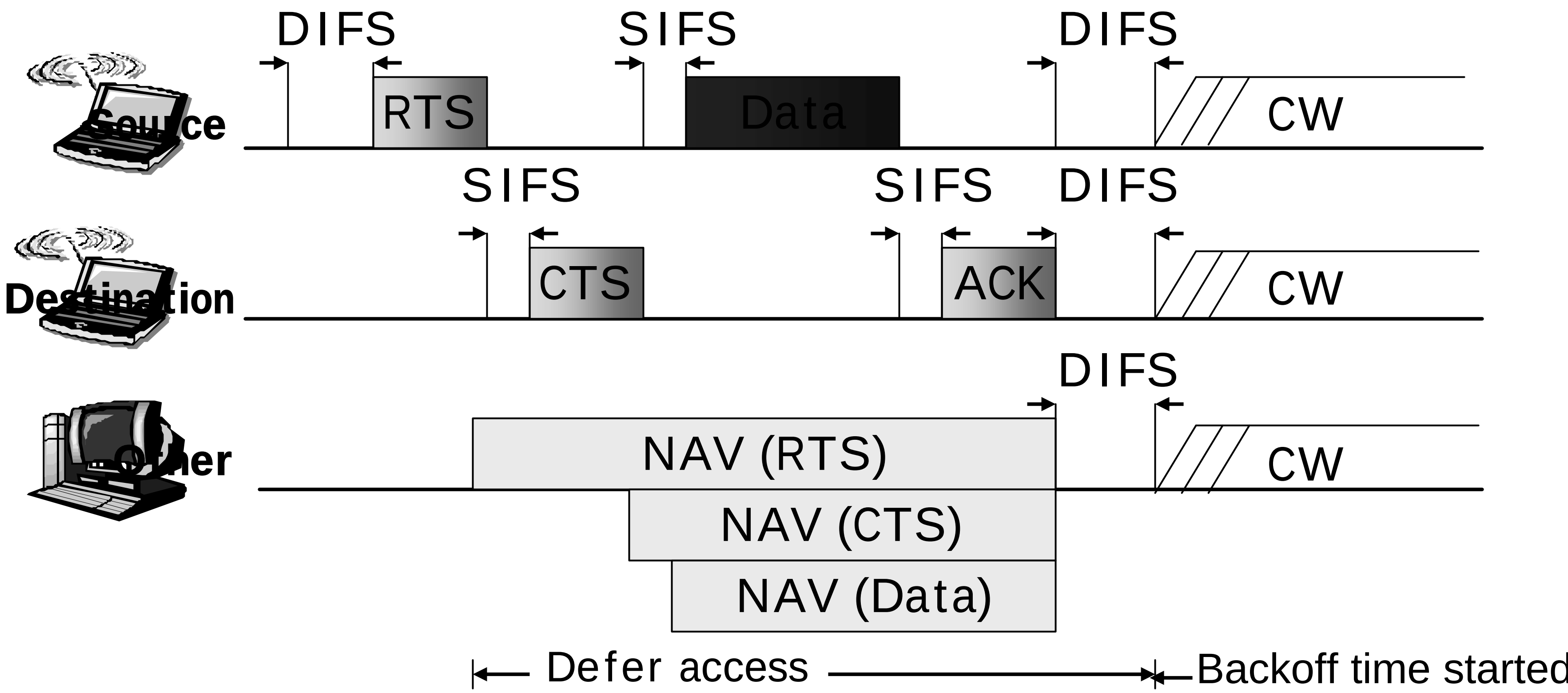
Wireless LANs based on the IEEE 802.11x standard have been phenomenally successful



Generic 802.11 WLAN Architecture

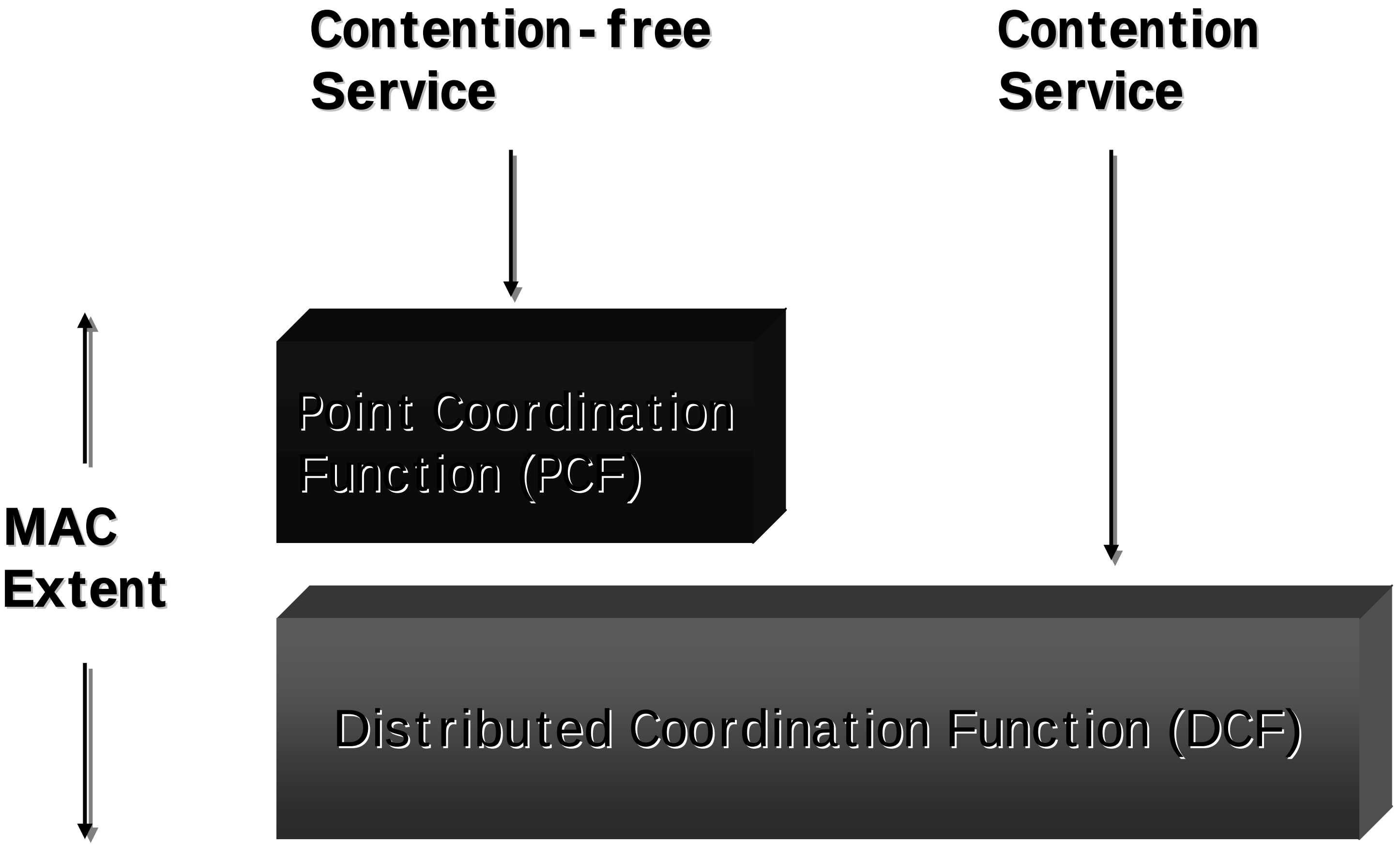


DCF (CSMA/CA)

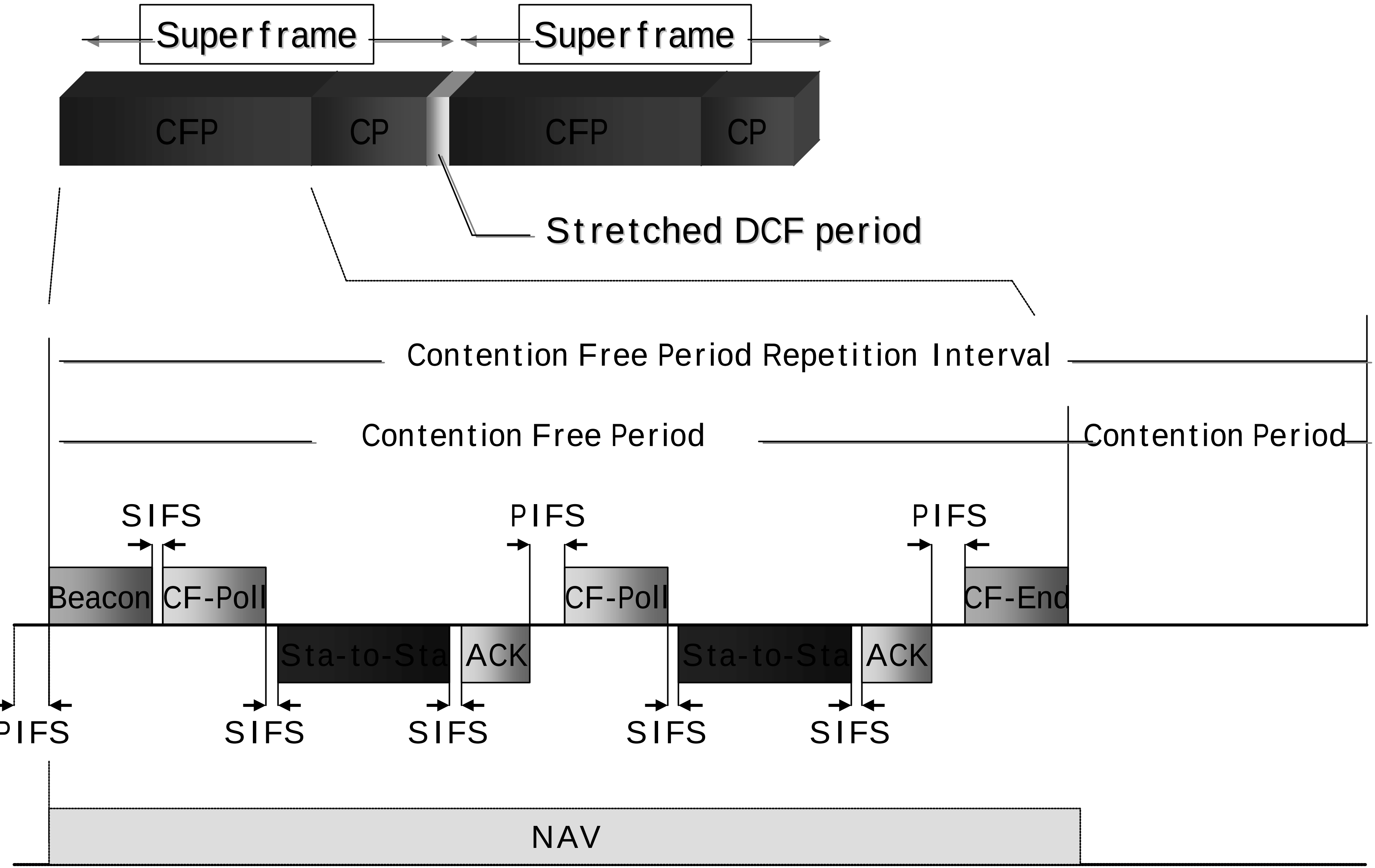


Backoff time: $\left\lfloor ranf() \bullet 2^{2+i} \right\rfloor \bullet Slot\_Time$

MAC Architecture



PCF


Superframe
Superframe
CFP
CP
CFP
CP
Stretched DCF period
Contention Free Period Repetition Interval
Contention Free Period
Contention Period
SIFS
PIFS
PIFS
Beacon
CF-Poll
CF-Poll
CF-End
Sta-to-Sta
ACK
Sta-to-Sta
ACK
PIFS
SIFS
SIFS
SIFS
SIFS
NAV

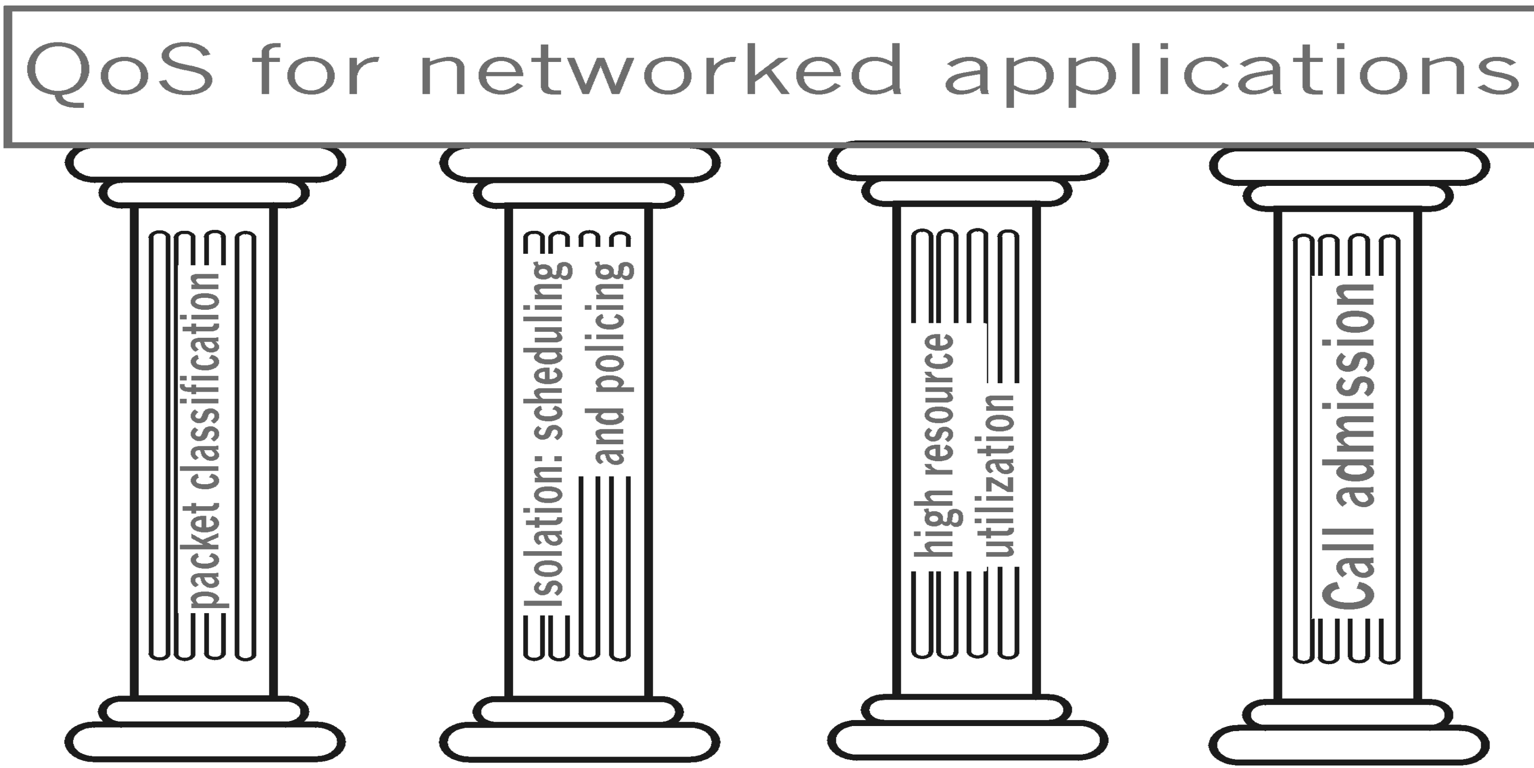
Motivation

- Packet-switched solutions that ta advanta of sileness in a given voice call by multiplex ther calls are more bandwidth-ef solutions
- In wireless netw ed
- integrated multime ude any priority and ac
- PCF mo witched connection-oriented" servi which well su for telephony traffic
- In order to poll the stations an AP must maintain a polling list, which is implementation dependent

The use of packet -switched techniques for carrying multimedia traffic in 802.11 WLANs are indeed needed

Bandwidth management and QoS

- IETF groups are working on proposals including RSVP, Differentiated Services, and Integrated Services to provide better QOS control in IP networks



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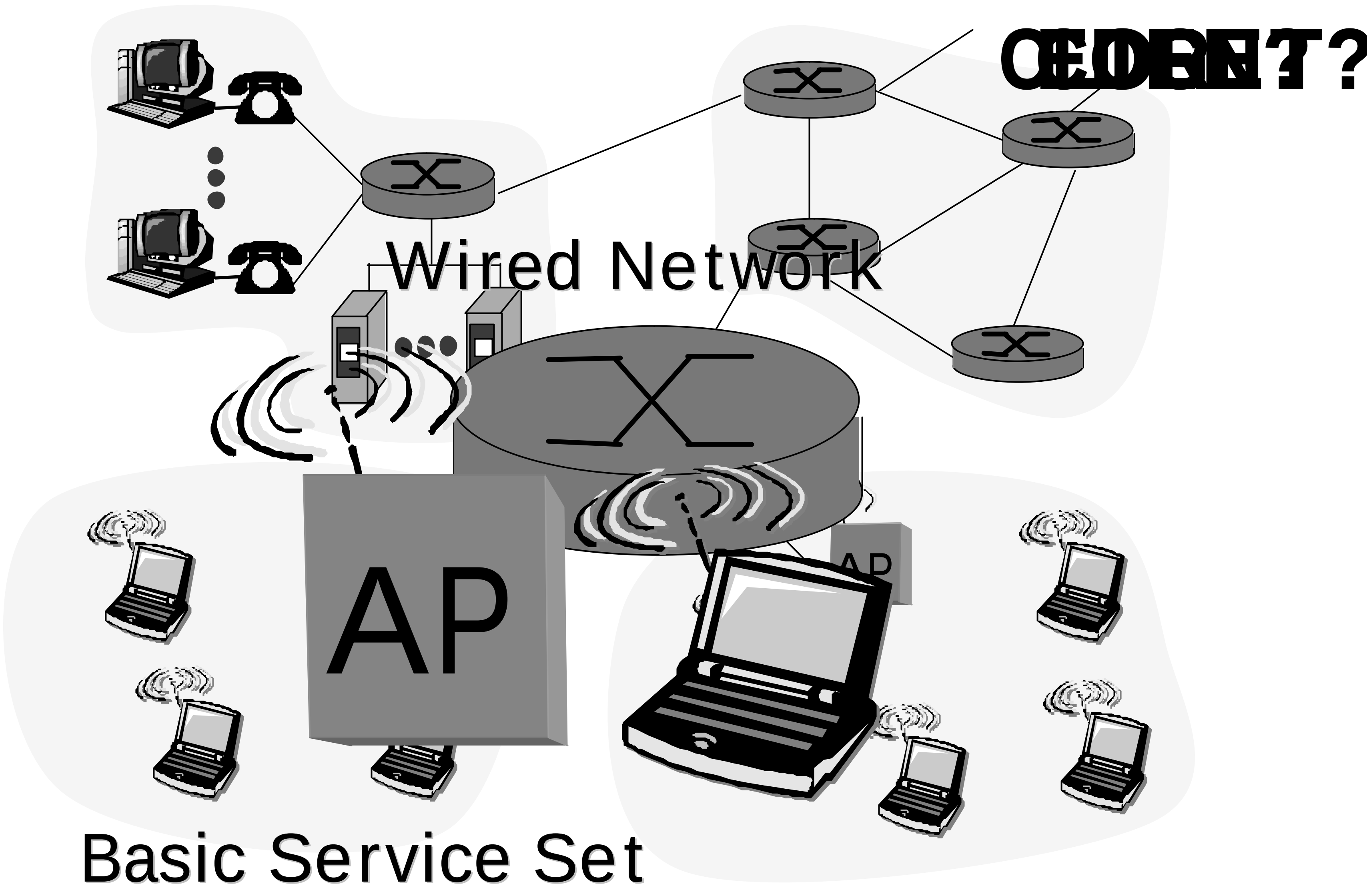
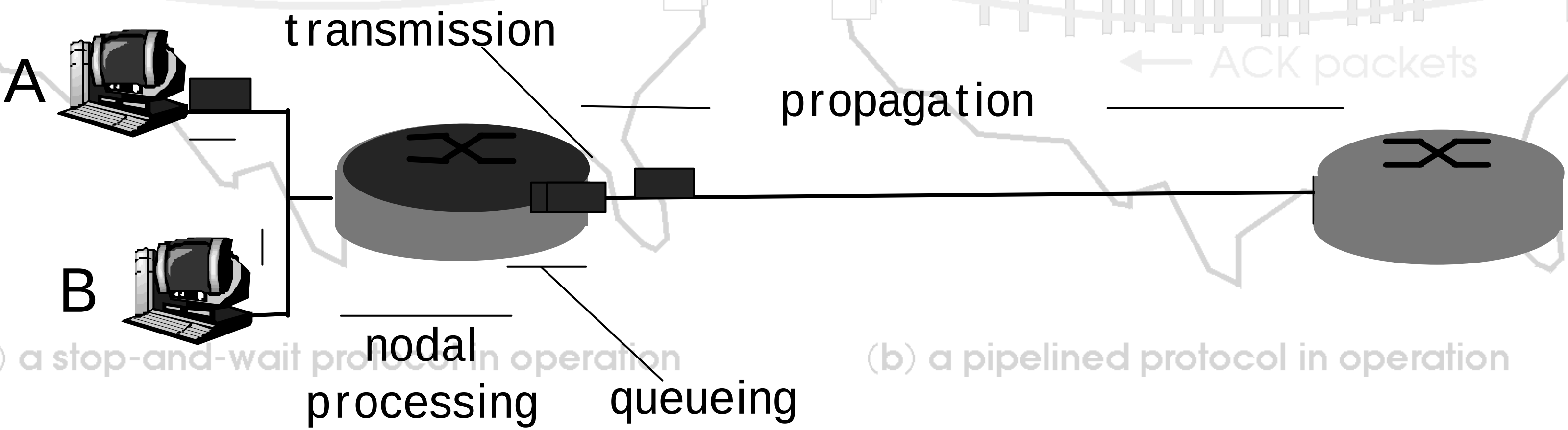
Should we support these functionalities in..



Delay in packet-switched networks

$$= \frac{8kbits}{10^9\, bits/\sec} = 8 micro\sec onds$$

$$= \frac{5000km}{3\times 10^8\, m/\sec} = 16.6 mili\sec onds$$



$$(8\times 10^{-6} + 16.6\times 10^{-3})\times 10^9 \big/ 10^3 = 16000.608\, packets$$

Issues in Mobile Terminal Design

Basic Components

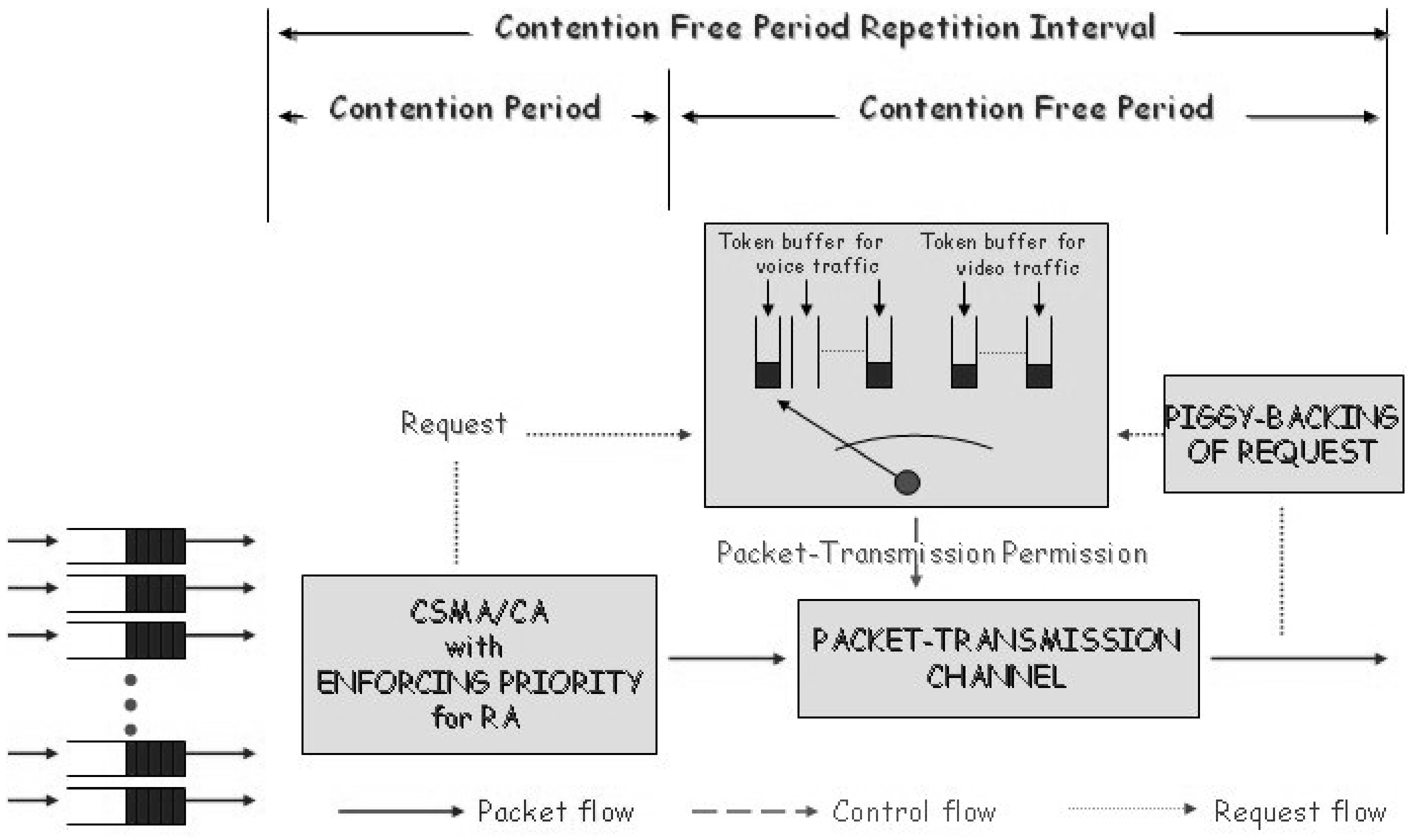
- Priority Enforcement Mechanism for Request Access collision

  Packet classification

Types of requests (k, m, n) / Backoff slot numbers / Consecutive times (i)	1st	2nd	3 rd	4 th
Real-time handoff traffic (0, 1, 1)	0 – 3	0 -7	0 – 15	0 – 31
Admitted inactivated video traffic (1, 1, 1)	4 – 7	8 - 15	16 – 31	32 - 63
Non-real-time handoff traffic New request traffic (2, 2, 1)	8 – 15	16 - 31	32- 63	64 – 127

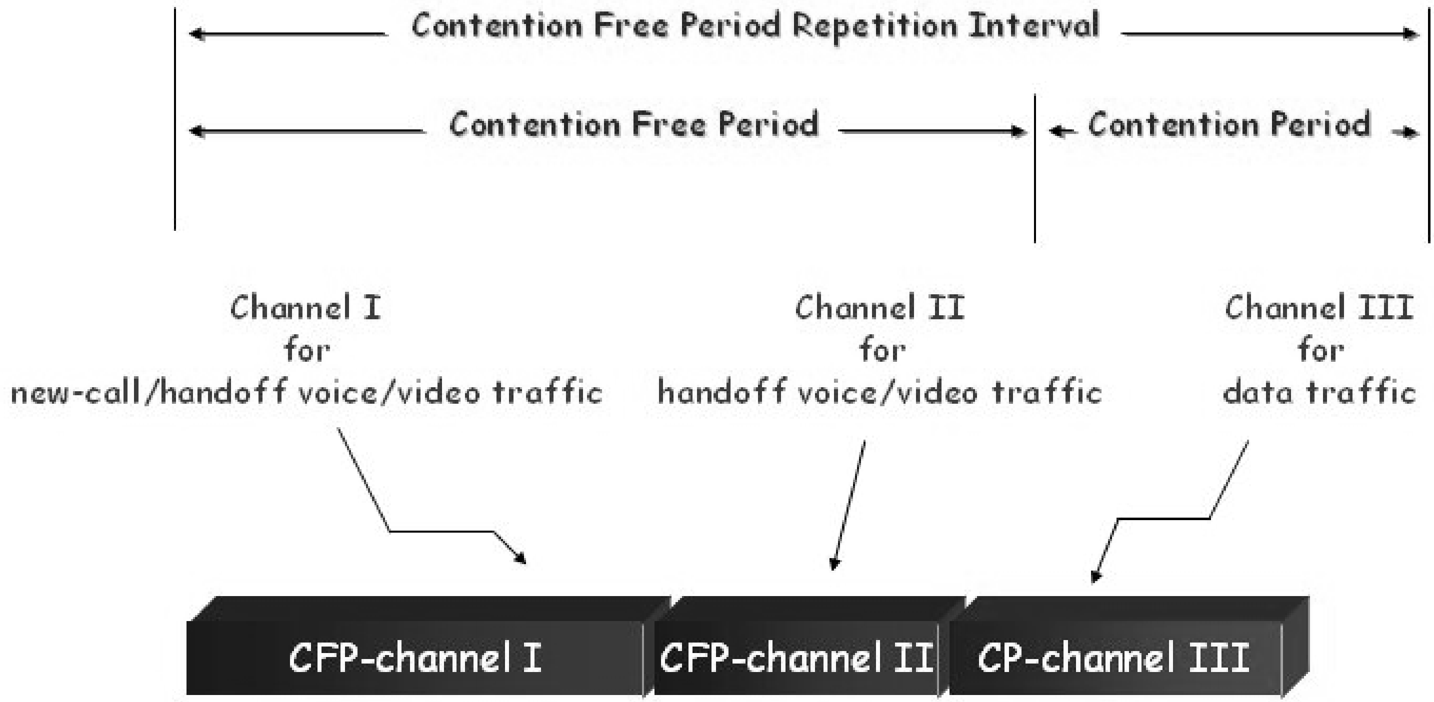
Basic Components

- The Packet Transmit-permission Policy
  Isolation + Call admission

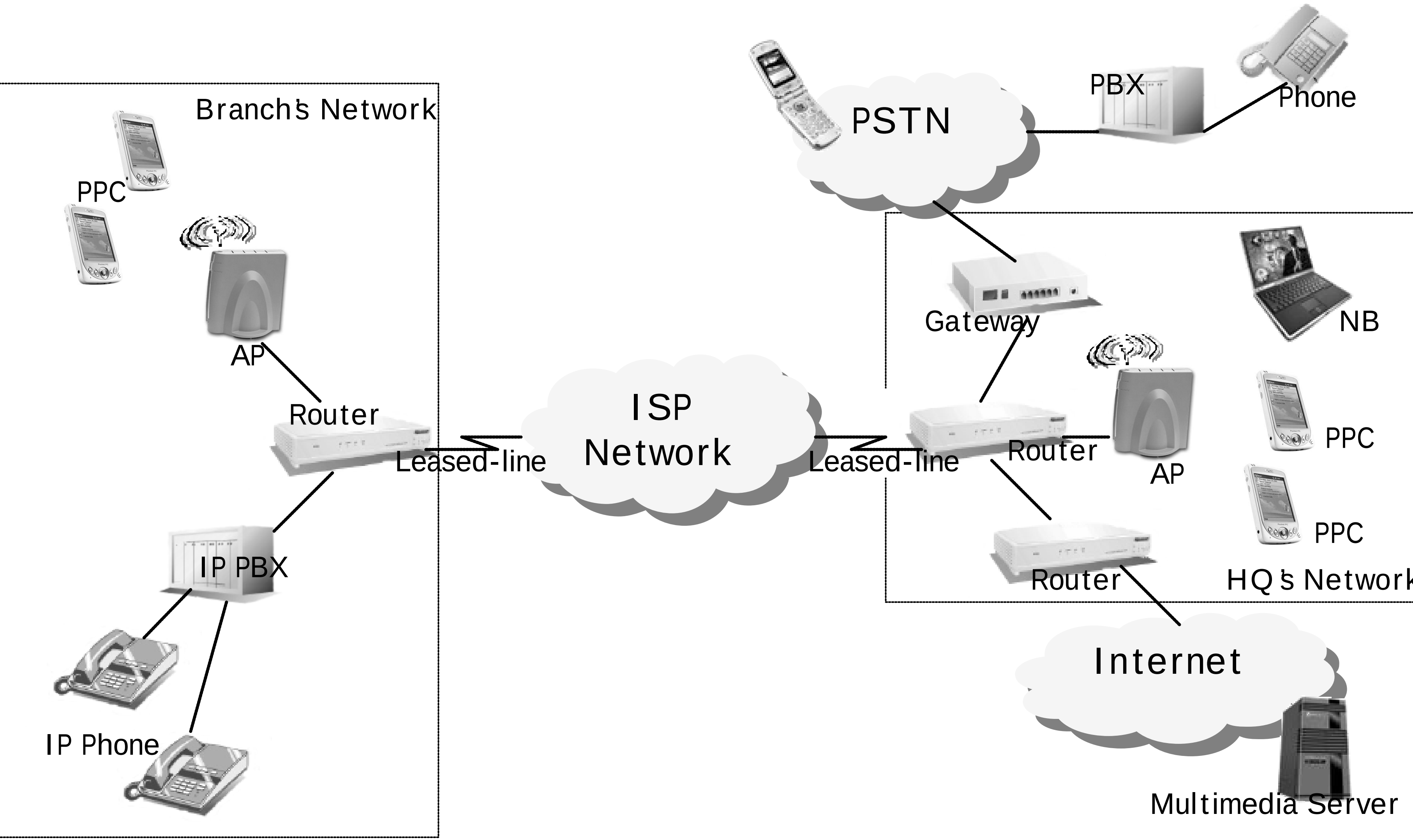


Basic Components

- The Adaptive Bandwidth Management Strategy
  High resource utilization



System Architecture



Enforcing priority for RA

Too support priority, we change the backoff time generation function

$$\left\lfloor ranf() \cdot 2^{2+i} \right\rfloor \rightarrow \left\lfloor ranf() \cdot 2^{m+i} \right\rfloor + k \bullet 2^{n+i}$$

Types of requests (k, m, n) / Backoff slot numbers / Consecutive times (i)	1^{st}	2^{nd}	3^{rd}	4^{th}
Real-time handoff traffic (0, 1, 1)	**0 – 3**	**0 -7**	**0 – 15**	**0 – 31**
Admitted inactivated video traffic (1, 1, 1)	**4 – 7**	**8 - 15**	**16 – 31**	**32 - 63**
Non-real-time handoff traffic New request traffic (2, 2, 1)	**8 – 15**	**16 - 31**	**32- 63**	**64 – 127**

Backoff Alg. in Congested Scenarios

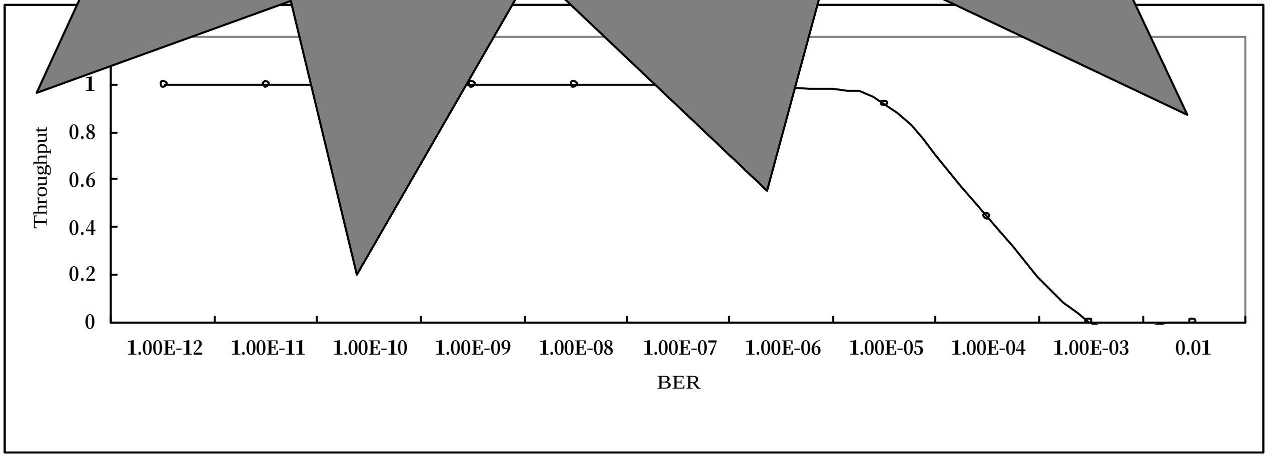
- The usage of backoff algorithm a… ds long ac… ess delays when the load is light because i… ct… ti… all) parameter value of contentio… suming a low level of conge…
- This strategy mi… ly to find out l… d, but each inc… e is obtained paying the… d… ge)
- After a… sion, the size of CW is set again to th… imum… lue wi… t maintaining any knowledge of th… e current c… annel statu… .

It incurs a high collision probability
and channel utilization is degraded
in bursty arrival or congested scenarios

Backoff Alg. in Noisy Channels

- In DCF access method, immediate po… e acknowledgement in… ms the sen… successful re… n of each … me
- In ca… ender will pr…
- Un… hi… of receivin… n 30%.

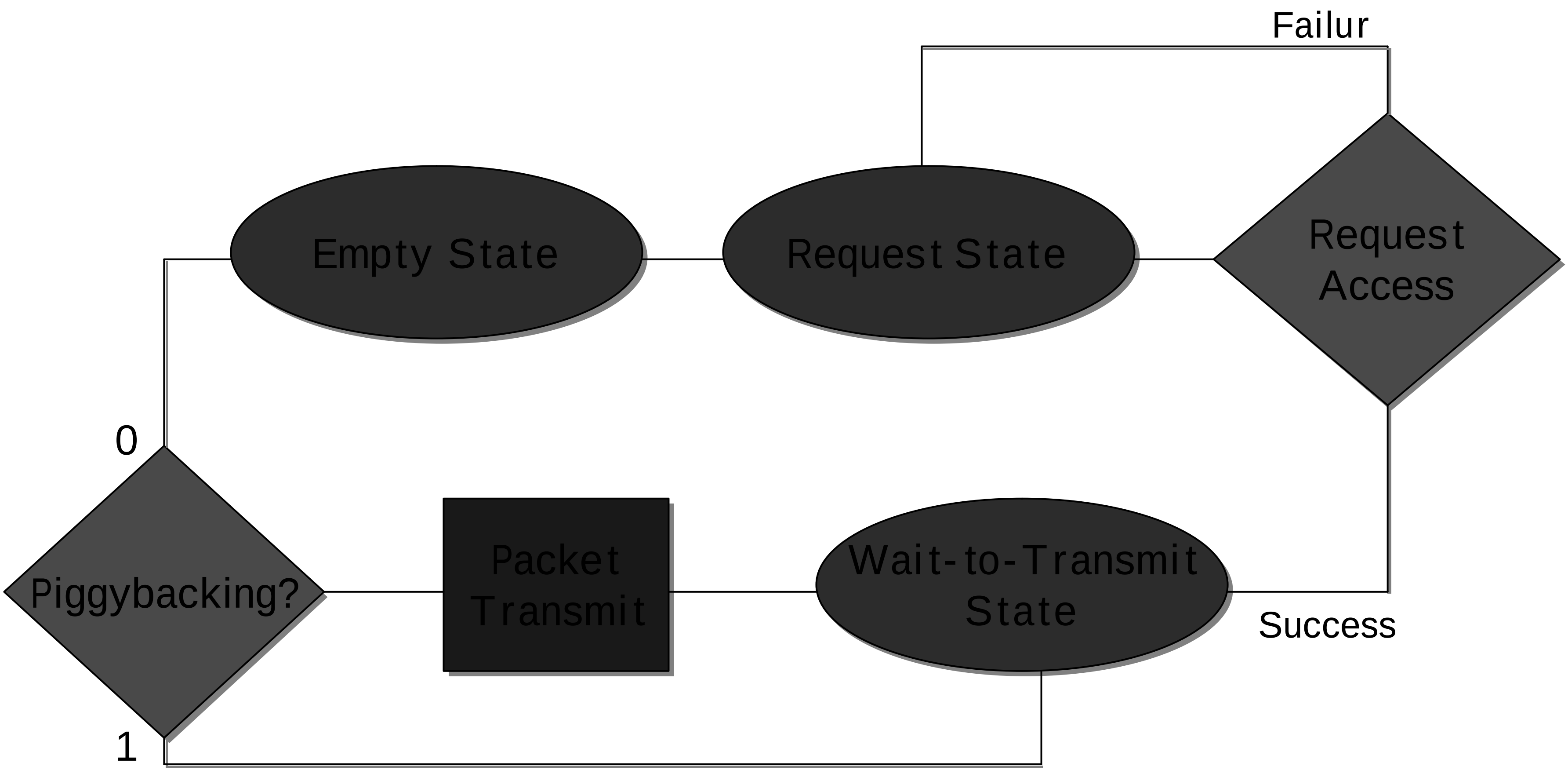
When a frame is collided on wired network, the sender should slow down
When one is lost on a wireless network the sender should try harder



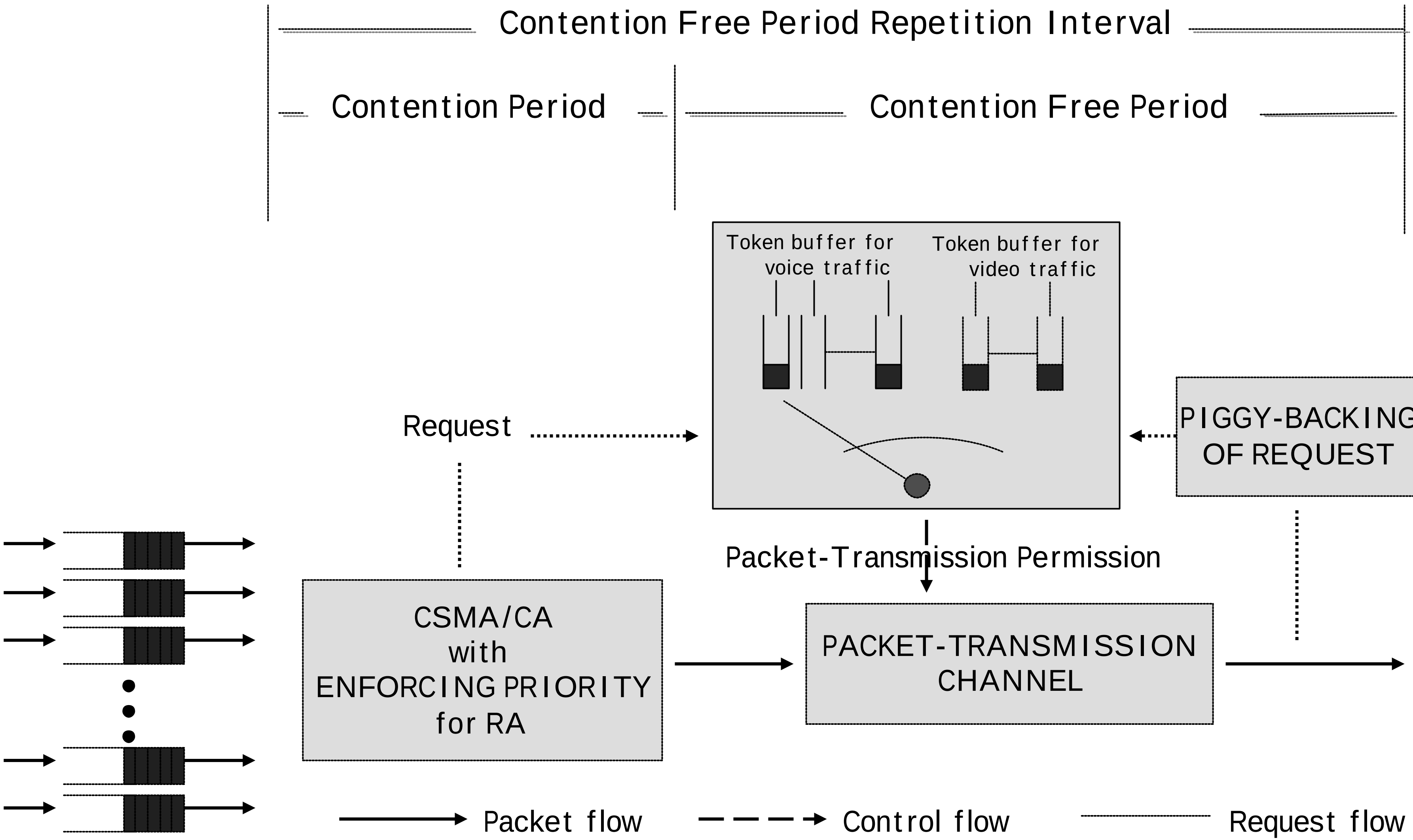
Optimal contention window

- Step 1: $$p_{opt} \geq \frac{a}{M} = \frac{a}{1 + \dfrac{\log\left(\dfrac{1-a}{(1-BER)^{t_{slot}/1-q}}\right)}{\log\left(1 + \dfrac{2\cdot(1-2\cdot a)}{(2+W)\cdot a + W\cdot a\cdot(2\cdot a)^m - (1+W)}\right)}}$$
- Step 2: $$Optimal\_CW = \frac{2}{p_{opt}} - 1$$
- Step 3: $$\mathrm{New\_CW} = \chi \cdot \mathrm{Current\_CW} + (1-\chi)\cdot \mathrm{Estimate\_Optimal\_CW}$$
- Step 4: $$\left\lfloor ranf() \cdot 2^{\lceil \log(New\_CW) \rceil} \right\rfloor \cdot t_{slot}$$

Cnannel Model for RT Station



Packet scheduling policy in CFP



Packet scheduling policy in CFP

1) The AP first scans the token buffers of voice sources according to the preset priority order. If a token is found, it removes one from this token buffer and polls this voice terminal. On receiving a poll the station transmits its packet after a SIFS interval. Then, the AP generates the next token for this voice source after $1/r_c - (2 \cdot \mathrm{SIFS} + \mathrm{CFPoll} + t_p + \mathrm{ACK})$ second if the piggyback was set while transmitting the packet.
2) If no tokens are found in the token buffers of voice sources, the AP continues to scan the token buffers for video sources according to the preset priority order. If a token is found, it polls this video source. And it will not remove the token if the piggyback was set while this video source transmit it packet. If the piggyback was not set and it is not the last packet (End-of-File) either, the AP removes the token, and then generates the next token for this video source after h seconds
3) If there is no token found in all token buffers, the AP will not know which, if any, of the stations have packets to transmit, then, it can end the CFP by transmitting a CF-End frame, and, for assuring the time constraint of admitted real-time traffic, the AP shall announce the beginning of the next CFP interval by observing the token buffer of highest priority among its polling list.

Admission Control for voice traffic

- Let $d_i^* = t_p + \sum_{k=1}^{i-1} \left\lceil \frac{r_{ck}}{r_{ci}} \right\rceil \bullet t_p$, $i = 1,\ldots,n_c$

$$t_p = 2 \cdot SIFS + CFPoll + Packet + ACK$$

If $d_i^* < 1/r_{ci}$ and $d_i^* \le d_i$ for all i =1,2… , n_c, then all the packets generated by new-call voice sources meet their jitter constraints.

Furthermore, if $d_i^* + p_i < 1/r_{ci}$ and $d_i^* + p_i \le d_i$ for i^{th} sources which is handed off from other cells, then the packet generated by the i^{th} source after the handoff meets its jitter constraint.

Admission Control for video traffic

- Let $\bar{b}_0 = t_p \bullet (n_c + 1)$, $\bar{r}_{v0} = t_p \bullet \sum_{i=1}^{n_c} r_{ci}$, $\bar{b}_j = t_p \bullet (b_j + 1)$, $\bar{r}_{vj} = t_p \bullet r_{vj}$,

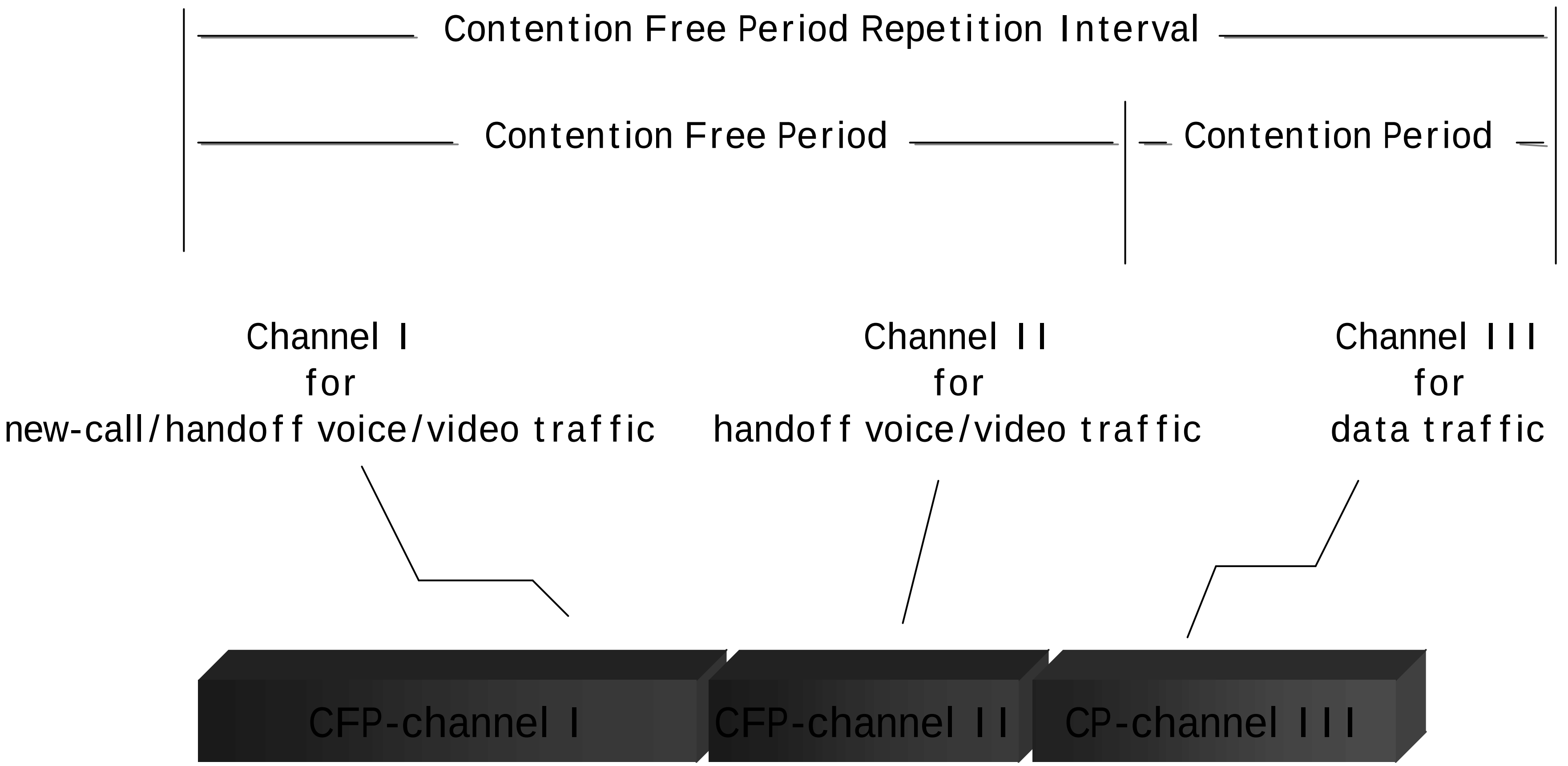
  and $d_j^* = h_j + \dfrac{\sum_{k=0}^{j} \bar{b}_k + t_p \bullet \sum_{k=1}^{j-1} (r_{vk} \bullet d_k^*)}{1 - \sum_{k=0}^{j-1} \bar{r}_{vk}}$, where $j = 1, \ldots, n_v$.

  If $\sum_{k=0}^{n_v} \bar{r}_{vk} \le 1$ and $d_j^* \le d_j$ for all j, then the delay constraints are satisfied for all the new-call video sources. Furthermore, if $d_j^* - h_j \le d_j - p_j$ for j^{th} source which is handoff from other cells, then the packet generated by the j^{th} source after handoff meets its delay constraint.

Minimized Ave. Waiting Time

- Suppose n_c voice sources are scheduled in the given priority order. The average waiting time is minimized for voice packets if $r_{ci} \leq r_{cj}$ for all $i < j$.

Adaptive Bandwidth Allocation Strategy



Adaptive Bandwidth Allocation Strategy

IF monitored dropping probability > threshold_D **THEN**

IF bandwidth utilization < m **THEN**

size of allocated bandwidth II= min {max {size of allocated bandwidth I, size of allocated bandwidth II} up_ g , total bandwidth }

ELSE

size of allocated bandwidth II= min {max {size of allocated bandwidth I, size of allocated bandwidth II} up_ g , total bandwidth threshold_up_II }

ELSE

Adaptive Bandwidth Allocation Strategy (cont'd

IF monitored blocking probability > threshold_B **THEN**
  IF bandwidth utilization < m **THEN**
   size of allocated bandwidth I = min {size of allocated bandwidth I up_ g , total bandwidth threshold.1_up_I }
  ELSE
   size of allocated bandwidth I = min {size of allocated bandwidth I up_ g , total bandwidththreshold.2_up_I }
ELSE
  IF bandwidth utilization < **THEN**
   size of allocated bandwidth II = max {size of allocated bandwidth II down_ g , total bandwidththreshold_down_II }
   size of allocated bandwidth I = max {size of allocated bandwidth I down_ g , total bandwidththreshold_down_I }

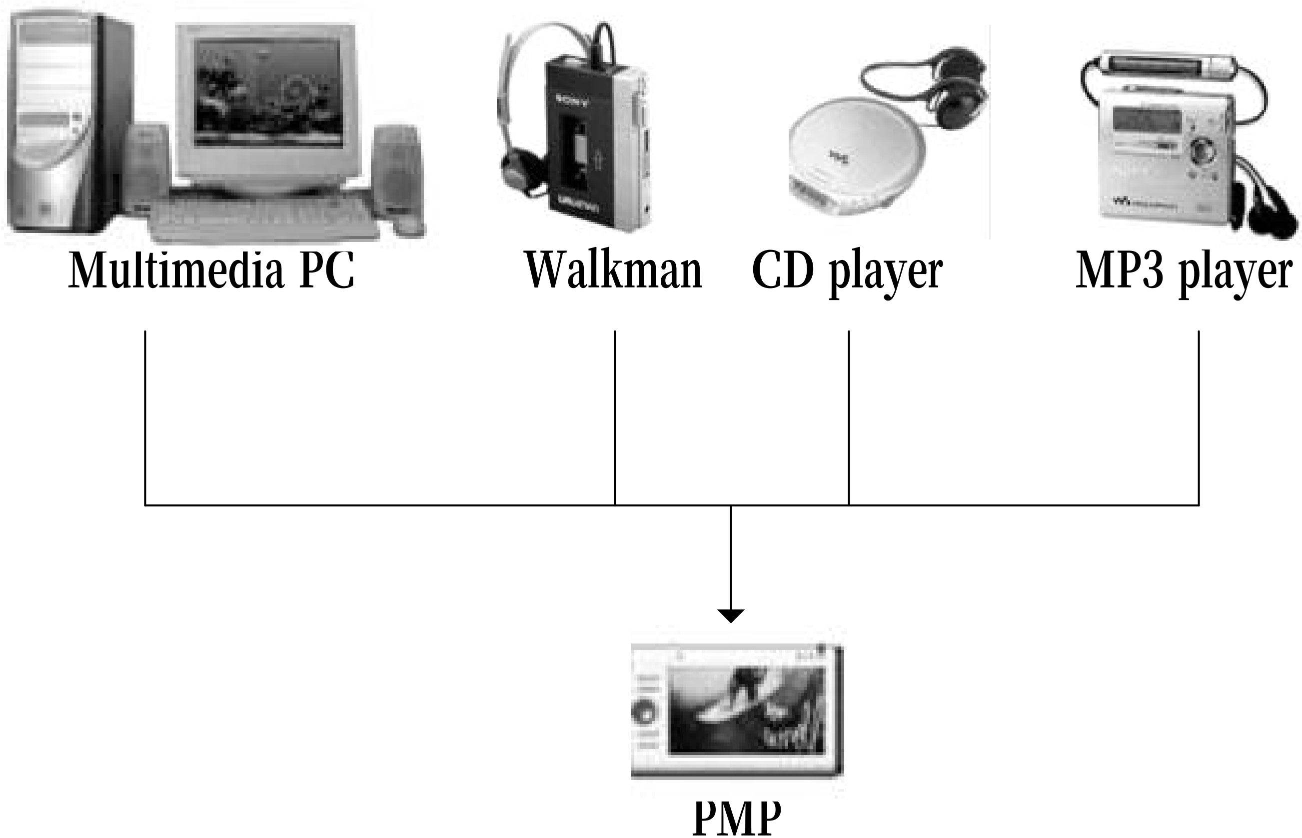
Conclusions

- A feasible and pragmatic non-preemptive priority based access control scheme was proposed
- Prioritization is key to optimizing overall performance
- Various QoS requirements are needed in the future
- Multilevel priorities, bandwidth allocation, connection admission control, and traffic policing all need to be considered together in the future networks
- There's no such thing as a free lunch

  Ongoing efforts to provide "perfect" solutions have illustrated that attempts to solve all possible problems result in technologies that are far too complex, have poor scaling properties, or simply do not integrate well into the diversity of the Internet.

  Besides, we believe that it is almost impossible to increase the probability of success of transmitting a frame excepting frames fragmentation or FEC (Forward Error Control) in an extremely noisy wireless environment.

Project (鉅格)



Project (鉅格)

Future Digital Home System