Review and Update of Carrier Extension Proposal

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Outline

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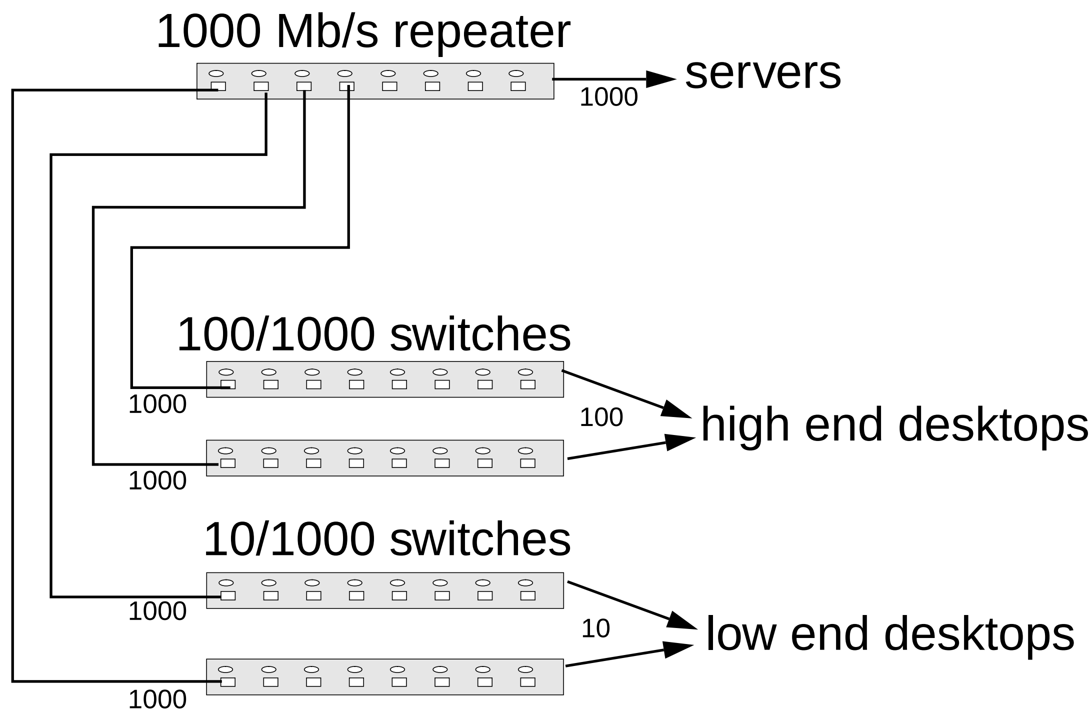
Introduction

- Scaling CSMA/CD to 1000 Mb/s is a good idea
  - Widely implemented, well understood protocol
  - Demonstrated low cost at 10 and 100 Mb/s
  - Cost benefit of 1000 Mb/s shared versus 1000 Mb/s switched
- Scaling CSMA/CD to 1000 Mb/s is slightly more complicated than scaling it to 100 Mb/s
  - Wire delays are 10x larger (in BT) than at 100 Mb/s
  - "shift the decimal point" approach results in a ridiculously small collision domain diameter
- Backwards compatibility with 10 and 100 Mb/s is essential

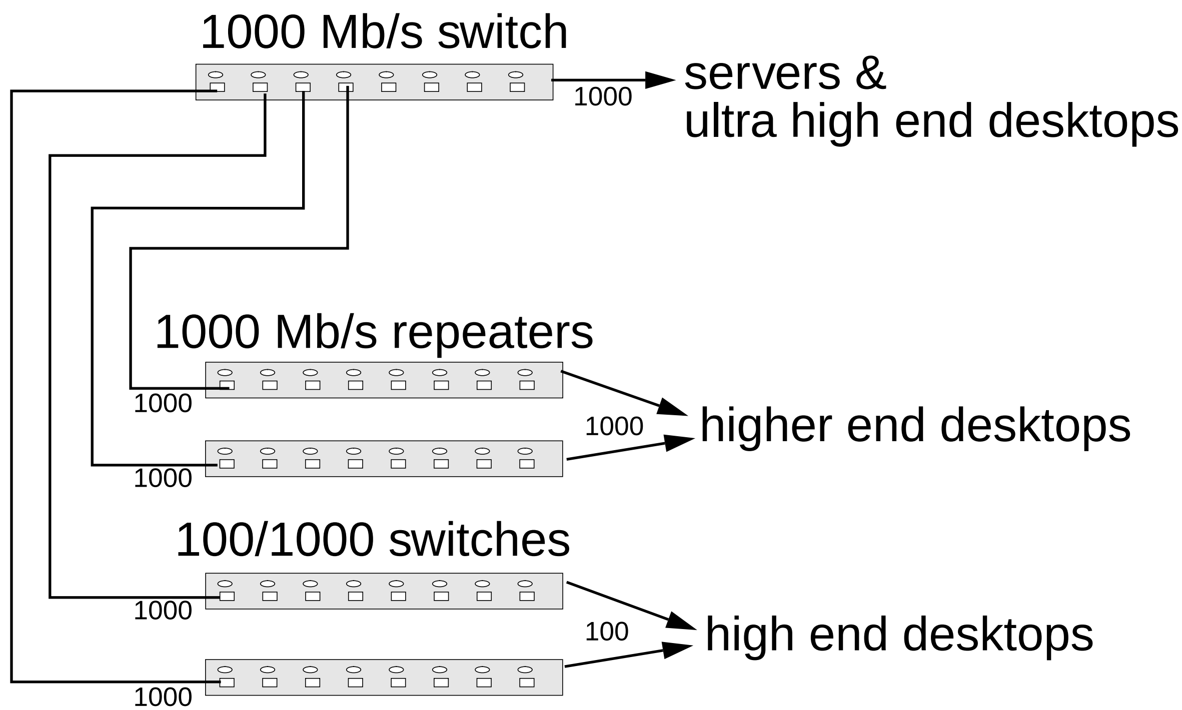
Topologies

- **Most useful CSMA/CD topologies have at least one repeater**



CSMA/CD used in a single repeater collision domain
within a server room

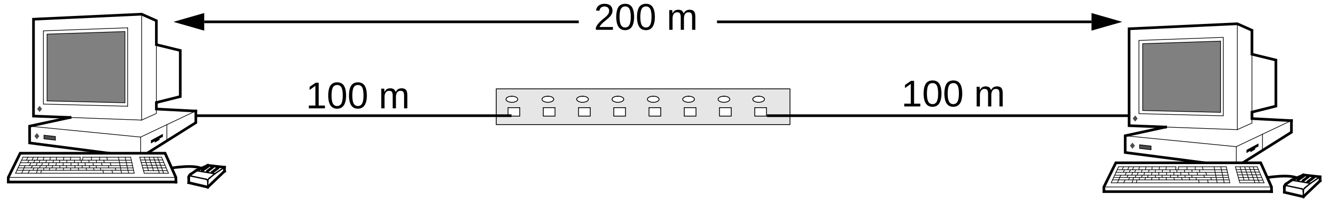
Topologies (cont)



CSMA/CD used in single repeater collision domains
with 1000 Mb/s horizontal runs

Topologies (cont)

- Horizontal runs are 100 meters maximum
- A CSMA/CD topology with horizontal runs out to desktops must support a diameter of at least 200 meters



Bit Budgets

- Bit budget calculations are highly dependent on:
  - Physical layer signalling method and architecture
  - MAC <=> PHY data path width
  - MAC state machine frequency
  - Repeater data path width
  - Repeater state machine frequency
  - Fairness issues
- See Stephen Haddock's presentation for an updated bit budget analysis

Bit Budgets (cont)

- Conclusions from bit budget analysis
    - Cable delay dominates, but even with short cables, the bit budget exceeds 512 BT
    - DTE and repeater delay estimates may be optimistic
    - The minimum frame size must be increased from 512 bits to achieve useful topologies at 1000 Mb/s
- Recommend a new minimum frame size of 512 Bytes
    - Simply change bits to bytes!

Issues

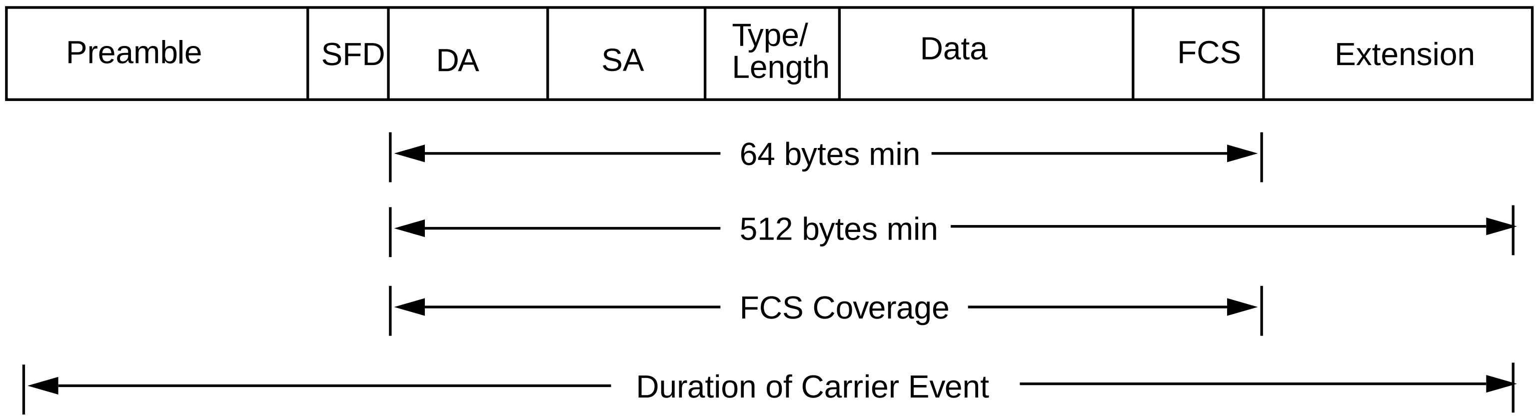
- It’s not that simple
- Trying to solve the problem by increasing the minFrameSize to 512 Bytes has harmful side effects
  - Degrades maximum small packet rate on full duplex links where it is not necessary to use the larger minimum size
  - Can’t propagate the inflated packets to 100 Mb/s or 10 Mb/s networks, the performance loss would be hideous
  - Can’t rely on the padding/stripping mechanism in the 802.3 MAC when using protocol stacks which use the Ethernet frame format
- Must find a way to extend the minimum frame size only on 1000 Mb/s, CSMA/CD networks, regardless of whether Ethernet or 802.3 frame format is used

Solution

- Conceptually, extend the duration of the carrier event without extending the data field, or altering the FCS field
- Introduce a new mechanism which appends non-data symbols to the end of short frames
- Extend the collision window to include these symbols
- Include the extension in the fragment discard calculation
- Remove the extension before checking the FCS and passing the frame to LLC

Solution (cont)

- **Frame extension**



- **The extension symbols are non-data symbols, and are recognized as such by the MAC and the PHY**
- **The extension starts on an octet boundary, and is an integer number of octets in length**

Impact on MAC

- **New const (4.2.7.1)**

  const

  extendSize = ...; {in bits, implementation-dependent, see 4.4}
  extensionBit = ...; {a new type of non-data bit}

- **New Transmit State Variable (4.2.7.2)**

  var

  extension:0..extendSize; {length of extension}

- **New Receive State Variable (4.2.7.3)**

  var

  extendCount: 0..extendSize; {count of extension bits at end of frame}

Impact on MAC

- **Mod to StartTransmit (4.2.8)**

```
procedure StartTransmit;
begin
   extension := 0;
   currentTransmitBit := 1;
   lastTransmitBit := frameSize;
   transmitSucceeding := true;
   transmitting := true;
   lastHeaderBit := headerSize
end; {StartTransmit}
```

- **Mod to StartReceive (4.2.9)**

```
procedure StartReceive;
   begin
         currentReceiveBit :=1;
         extendCount := 0;
         receiving := true
   end; {StartReceive}
```

Impact on MAC (Transmitter)

- **Mod to BitTransmitter (4.2.8)**

```
process BitTransmitter;
begin
   cycle {outer loop}
         if transmitting then
         begin {inner loop}
               if halfDuplex then (extension : = minFrameSize + extendSize);
               PhysicalSignalEncap; {send preamble and sfd}
               while transmitting do
               begin
                  if currentTransmitBit > lastTransmitBit then
                        TransmitBit(extensionBit)
                  else
                        TransmitBit(outgoingFrame[currentTransmitBit]);
                  if newCollision then StartJam else NextBit
               end;
         end; {inner loop}
   end; {outer loop}
end; {BitTransmitter}
```

Impact on MAC (Transmitter)

- **Mod to NextBit (4.2.8)**

```
procedure NextBit;
  begin
      currentTransmitBit := currentTransmitBit + 1;
      transmitting := ((currentTransmitBit ≤ lastTransmitBit)
                           or (currentTransmitBit ≤ extension))
  end; {NextBit}
```

- **Mod to StartJam (4.2.8)**

```
procedure StartJam;
  begin
      currentTransmitBit := 1;
      lastTransmitBit := jamSize;
      extension := 0;
      newCollision := false
  end; {StartJam}
```

Impact on MAC (Transmitter)

- **Mod to WatchForCollision (4.2.8)**

```
procedure WatchForCollision;
begin
   if transmitSucceeding and collisionDetect then
   begin
         if currentTransmitBit > (minFrameSize - headerSize + extendSize) then
               lateCollisionError := true;
         newCollision:= true;
         transmitSucceeding := false
   end
end {WatchForCollision}
```

Impact on MAC (Receiver)

- **Mod to BitReceiver (4.2.9)**

```
process BitReceiver;
   var b: Bit;
begin
   cycle {outer loop}
         while receiving do
         begin {inner loop}
         if currentReceiveBit = 1 then
               PhysicalSignalDecap; {strip off the preamble and sfd}
               b := ReceiveBit; {get next bit from physical Media Access}
               if receiveDataValid then
                  if b = extensionBit then
                  extendCount := extendCount + 1
                  else
                  begin {append bit to frame}
                        incomingFrame[currentReceiveBit] := b;
                        currentReceiveBit := currentReceiveBit + 1
                  end
         receiving := receiveDataValid
         end {inner loop}
         frameSize := currentReceiveBit - 1 + extendCount
   end {outerloop}
end; {BitReceiver}
```

Impact on MAC (Receiver)

- **Mod to ReceiveLinkMgmt (4.2.9)**

```
procedure ReceiveLinkMgmt;
begin
  repeat
      StartReceive;
      while receiving do nothing; {wait for frame to finish arriving}
      excessBits := frameSize mod 8;
      frameSize := frameSize - excessBits; {truncate to octet boundary}
      if halfDuplex then
      begin
          receiveSucceeding :=((frameSize ≥  (minFrameSize + extendSize));
          frameSize := frameSize - extendCount
      end
      else
          receiveSucceeding := (frameSize ≥ minFrameSize);
  until receiveSucceeding
end;
```

MAC Parameters

- **New Parameter Table 4.4.2.4**

Parameters	**Values**
slotTime	4096 bit times
interFrameGap	96 ns
attemptLimit	16
backoffLimit	10
jamSize	32 bits
maxFrameSize	1518 octets
minFrameSize	512 bits (64 octets)
addressSize	48 bits
extendSize	448 octets

Impact on Reconciliation Sublayer

- 22.2.1.1.2 Semantics of the service primitive PLS_DATA.request
  - Add EXTEND to the range of values communicated by the OUTPUT_UNIT parameter
- 22.2.1.2.2 Semantics of the service primitive PLS_DATA.indicate
  - Add EXTEND to the range of values communicated by the INPUT_UNIT parameter

Performance

- Simulations used “workgroup average” packet size distribution derived from some “real world” sampling

100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600		Packet Size (less than)
269	.079	.119	.006	.004	.343	.000	.000	.000	.029	.000	.000	.001	.000	.000	.151	1	Sun 100 WG 4.X
275	.527	.012	.005	.003	.006	.004	.002	.003	.016	.005	.002	.004	.008	.009	.123	2	AMD 10 WG
037	.039	.013	.121	.010	.012	.010	.010	.010	.010	.714	.000	.000	.001	.000	.014	3	Sun 100 WG Sol, w/ mc vid
206	.190	.088	.002	.066	.076	.062	.066	.066	.072	.066	.000	.000	.000	.000	.039	4	Sun 100 WG Sol w/o mc vic
530	.252	.018	.004	.005	.074	.005	.002	.001	.013	.012	.001	.001	.001	.001	.081	5	Sun 10 backbone
402	.236	.066	.000	.000	.014	.000	.000	.000	.000	.192	.000	.000	.000	.000	.090	6	3Com FDDI backbone
197	.209	.058	.034	.021	.109	.019	.020	.020	.032	.196	.001	.001	.002	.002	.082	7	WG AVG
466	.244	.042	.002	.003	.044	.003	.001	.001	.007	.102	.001	.001	.001	.001	.086	8	BB AVG
286	.220	.053	.023	.015	.087	.013	.013	.013	.023	.165	.001	.001	.002	.002	.083	9	AVG 1 thru 8

- See Mohan Kalkunte’s presentations for simulation results using “workgroup average” packet size distribution

Conclusions

- Useful CSMA/CD networks can be built at 1000 Mb/s
- The performance of the baseline proposal is adequate