Worst Case Buffer Requirements for TCP over ABR

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Overview

- Why ATM

- ABR and ERICA

- TCP over ABR/ERICA

- Generating Worst Case TCP Traffic

- Analytical/simulation Results

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Why ATM?

❑ ATM vs IP: Key Distinctions

    ❑ Traffic Management:
       Explicit Rate vs Loss based

    ❑ Signaling: Coming to IP in the form of RSVP

    ❑ PNNI: QoS based routing

    ❑ Switching: Coming soon to IP

    ❑ Cells: Fixed size or small size is not important

Old House vs New House
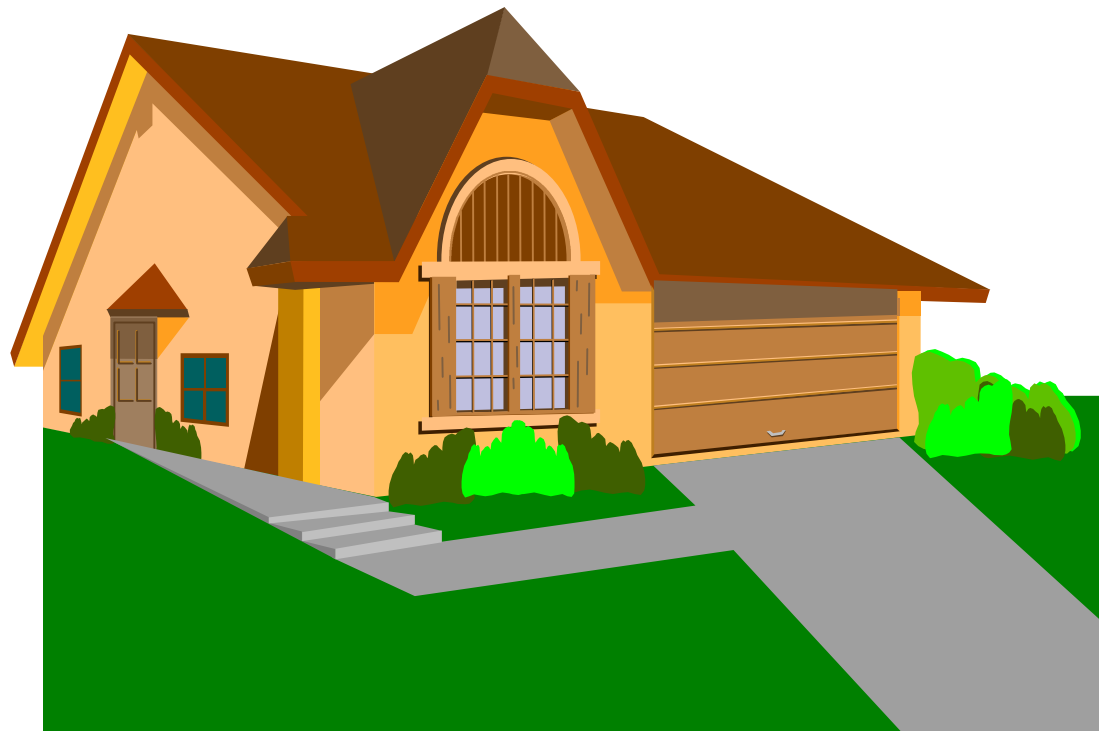
❑ New needs:
Solution 1: Fix the old house (cheaper initially)
Solution 2: Buy a new house (pays off over a long run)

TCP over ABR: Buffering

❑ Buffering depends heavily upon switch scheme.

❑ For the ERICA scheme and the traffic loads considered:

  ❑ W/o VBR, 3×RTT buffers will do for any number of TCP sources

  ❑ In general, $Qmax = a \times RTT + b \times Averaging\ Interval + c \times Feedback\ delay + d \times fn(VBR)$

❑ After TCP sources are rate-limited:
Switch queues become zero, source queues build up

Worst Case TCP Traffic

❏ Sources can retain high ACR, if they send packets within 500 ms.

❏ Many such sources with high ACR can dump a large amount of data

❏ Worst case is when all the sources dump the maximum window size

Worst Case (Cont)

- Each source sends one packet every 't' milliseconds. $t < 500$ ms.

- After several packets, the congestion window reaches the maximum for each source

- Sources synchronize and dump large burst at the same time.

- To avoid overload initially, the sources are uniformly spaced Þ kth source sends its first packet at '$k \times g$' µs.

N-Source Configuration
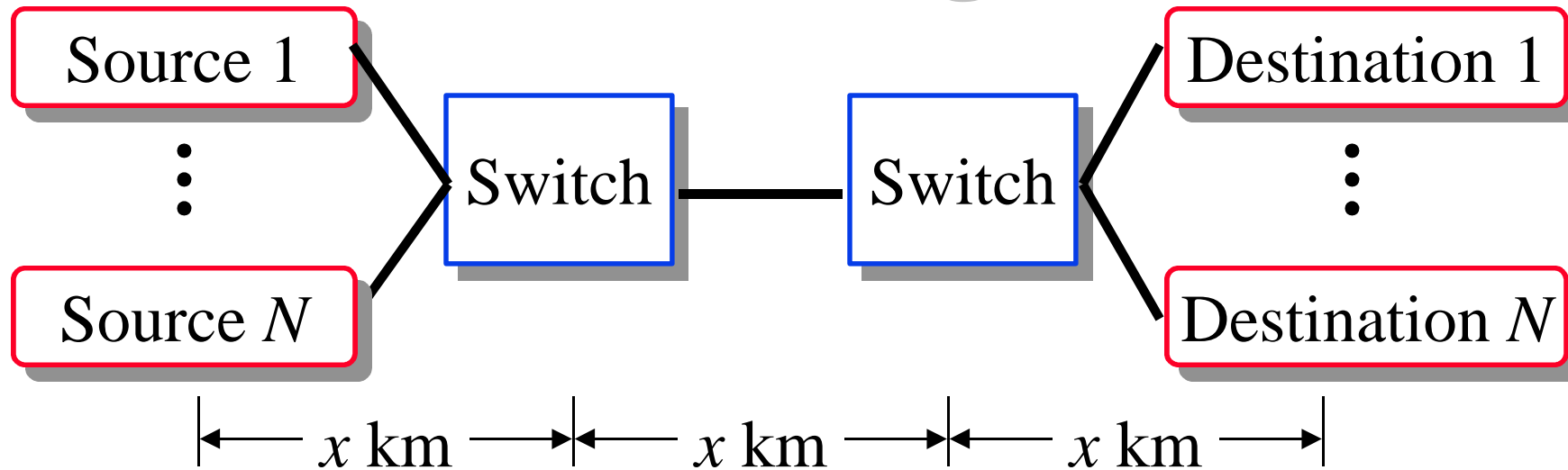
- All links 149.76 Mbps. Lengths $x = 2000, 1000$ km
- All traffic unidirectional. Worst case TCP traffic
- Parameters: # of sources={2, 3, 5, 10, 20, 30, …, 200} Infinite buffer size.

Analytical results

❑ Buffer requirement is reflected in maximum switch queue size.

❑ Let cwnd_max = Max congestion window of TCP

❑ When $N \leq \lfloor t/g \rfloor$

   ❑ Max Q length $\approx N \times$ cwnd_max/48 (formula 1)

❑ When $N > \lfloor t/g \rfloor$ ↰48 bytes/cell

   ❑ Max Q length = N*PCR*t   (formula 2)
   (PCR is peak cell rate)

❑ Queue length is given in terms of number of cells

Analytical results (Cont)

❑ With few sources, switch does not get congested even when sources reach their maximum window, ACRs can be high. Formula 1 applies here.

❑ With many sources, switch detects congestion and gives feedback. ACRs are low. Formula 2 applies here.

Simulation Parameters

❑ Source: Parameters selected to maximize ACR

TBE = 512

CDF (XDF) = 0.5

ICR = 10 Mbps

CRM (Xrm)= $\lceil$ TBE/Nrm $\rceil$

ADTF = 0.5 sec

PCR = 149.76 Mbps, MCR= 0, RIF (AIR) = 1,

Nrm = 32, Mrm = 2, RDF = 1/512, Trm =100ms,

TCR = 10 c/s

❑ Traffic: TCP/IP with worst case traffic

❑ Switch: ERICA+

Averaging interval = min{100 cells, 1000 μs}

Effect of Number of Sources

# TCP Srcs	Q Size (Cells)	
	Simul.	Analyt.
2	1575	2730
3	3149	4095
5	6297	6825
10	14131	13650
20	29751	27300
30	20068	11010
40	19619	14680
50	24162	18350
60	28006	22020

# TCP Srcs	Q Size (Cells)	
	Simul.	Analyt.
70	30109	25690
80	31439	29360
90	34530	33030
100	38088	36700
120	44939	44040
140	44744	51380
160	48880	58720
180	49961	66060
200	55618	73400

Effect of # of Sources (Cont)
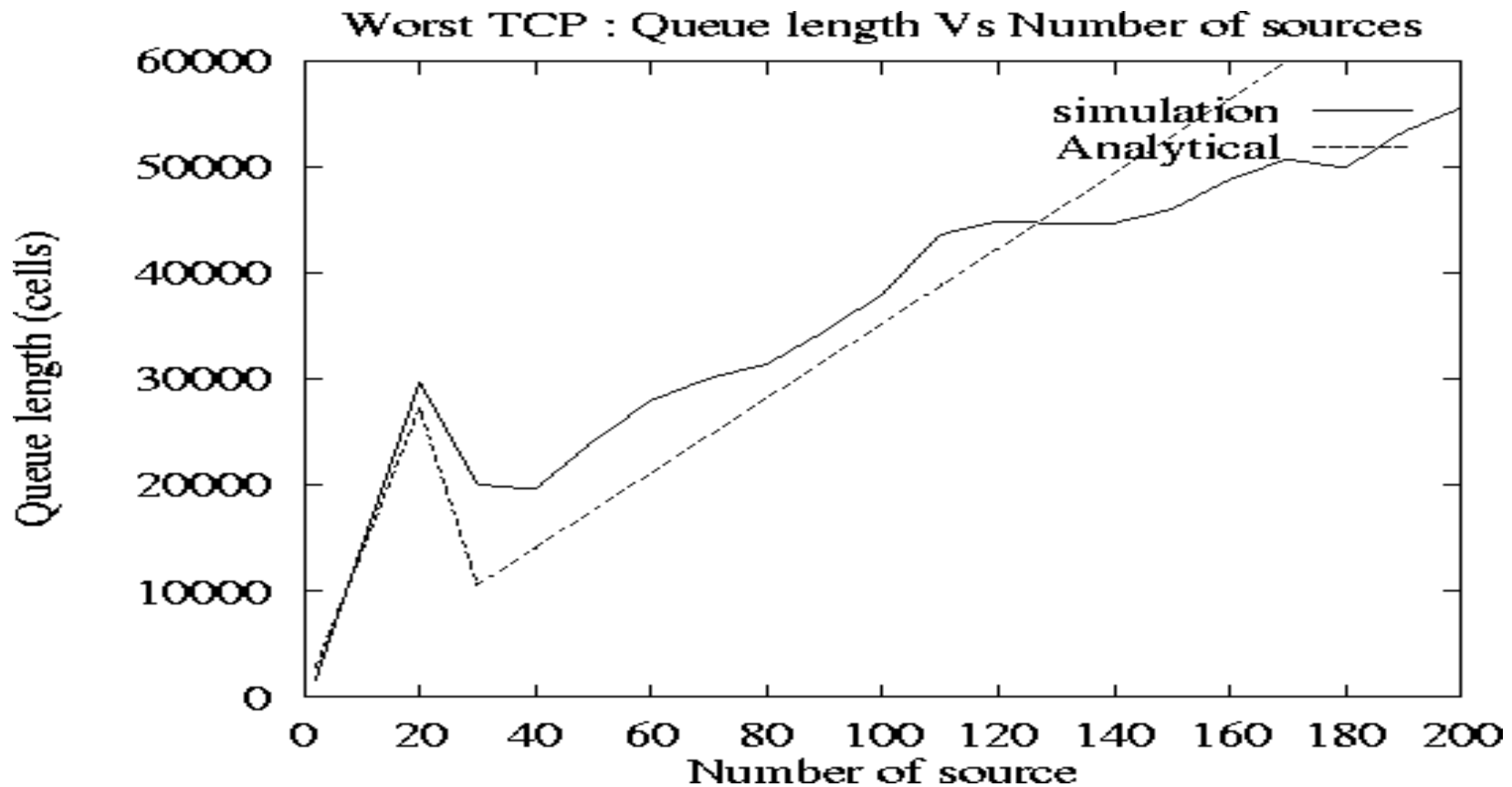
Effect of # of Sources (Cont)

❑ Analytical results: For $t = 1$ ms, $g = 50$ μs, MSS = 512 bytes, cwnd_max = 64 kB

   ❑ $Q = N*1365$ for $N \leq 20$ (formula 1)

   ❑ $Q = N*367$ for $N > 20$ (formula 2)

❑ The zig-zag shape is due to the two formulas

❑ The simulation agrees well with the analytical results for $N \leq 20$.

❑ The maximum queues occurred at predicted times (details in the contribution)

Effect of # of Sources (Cont)

❑ Buffer size increases linearly as number of sources increase

❑ As N increases, load increases
$\Rightarrow$ ERICA+ controls the queue lengths $\Rightarrow$ Less than analytical queue lengths

Sensitivity Analysis

#	mss/g/t/d	N=3	N=10	N=30	N=40	N=50	N=100
1	512/50/1/1000	3171	14273	20068	19619	24162	35687
2	512/50/1/2000	3171	14273	19906	27567	30872	75083
3	512/50/10/1000	3172	14274	45994	61854	77714	150453
4	512/50/10/2000	3172	14274	45994	61854	77714	150458
5	512/100/1/1000	3171	14273	19283	20080	24164	NA
6	512/100/1/2000	3171	14273	21241	32314	35961	NA
7	512/100/10/1000	3172	14274	45994	61854	77714	NA
8	512/100/10/2000	3172	14274	45994	61854	77714	NA
9	1024/50/1/1000	3040	13680	18650	18824	23542	NA
10	1024/50/1/2000	1542	5612	19131	22934	29163	NA
11	1024/50/10/1000	3040	13680	44080	59280	74480	NA
12	1024/50/10/2000	3041	13681	44081	59281	74481	NA
13	1024/100/1/1000	3040	13680	18591	19600	24314	NA
14	1024/100/1/2000	1403	5556	17471	24412	30533	NA
15	1024/100/10/1000	3040	13680	44080	59280	74480	NA
16	1024/100/10/2000	3041	13681	44081	59281	74481	NA

Sensitivity Analysis: Results

❑ MSS = 512, 1024 bytes, t = 1, 10 ms, g = 50, 100 μs, Link distance = 1000, 2000 km
Two values for each of the 4 parameters ⇒ 16 experiments.

❑ Segment size does not affect queue sizes

❑ If the network is not overloaded then round trip time has no effect (Expt. 3 and 4)

❑ If the network is overloaded then a larger round trip gives larger queue lengths (Expt. 1, 2 for N = 30, 40, 50)

Summary
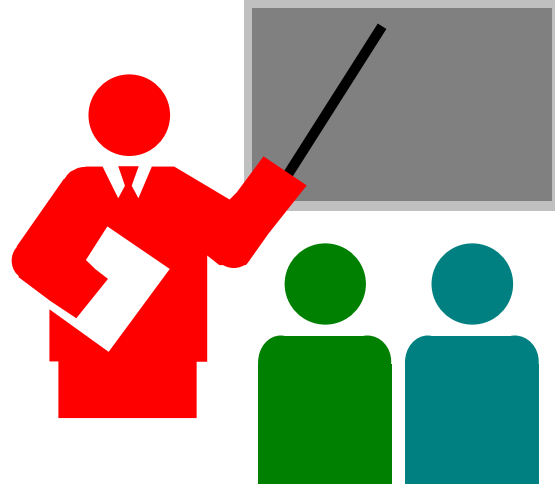
- ❑ Traffic management distinguishes ATM from other high-speed protocols

- ❑ ABR pushes congestion to edges.
  Buffering depends upon the switch algorithm

- ❑ ERICA requires $3 \times$RTT buffering for TCP

Summary (Cont)

❑ In worst case, the buffer requirements depend on the number of sources, network congestion status (overloaded or underloaded) and round trip time

❑ It is not affected by maximum segment size.

Our Contributions and Papers

❑ All our contributions and papers are available on-line at
http://www.cis.ohio-state.edu/~jain/

❑ See Recent Hot Papers for tutorials.

Thank You!