

# **ATM\_Forum/98-0830**

## **Packing Density of Voice Trunking using AAL2**

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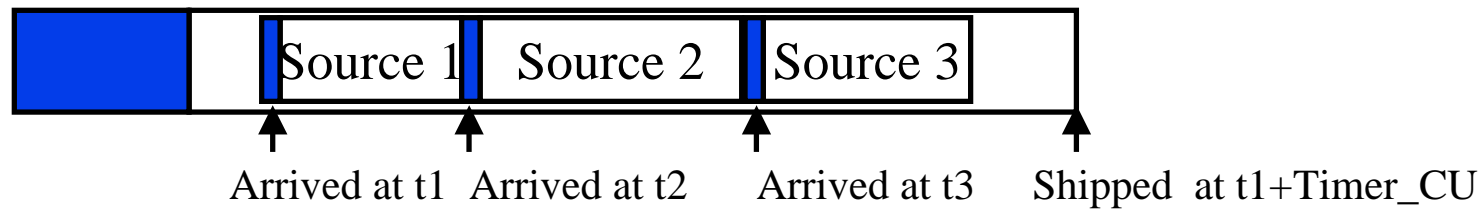
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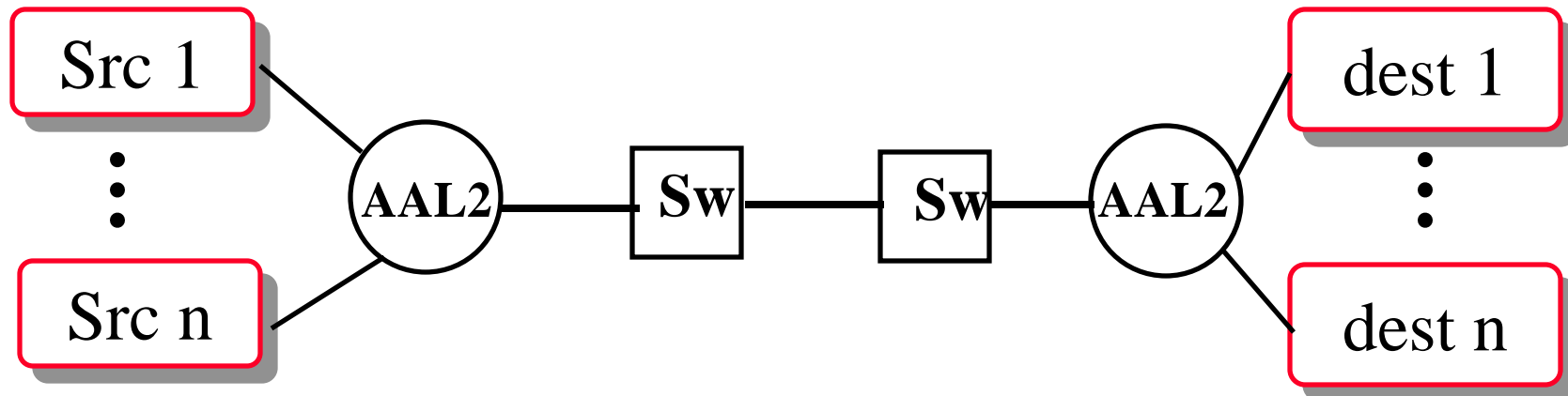
- ❑ AAL2 Voice Trunking and Timer\_CU
- ❑ Voice Model and Packet Arrival Pattern
- ❑ Markov Chain Analysis
- ❑ Comparison with Simulation Results
- ❑ Conclusion

# AAL2 Voice Trunking



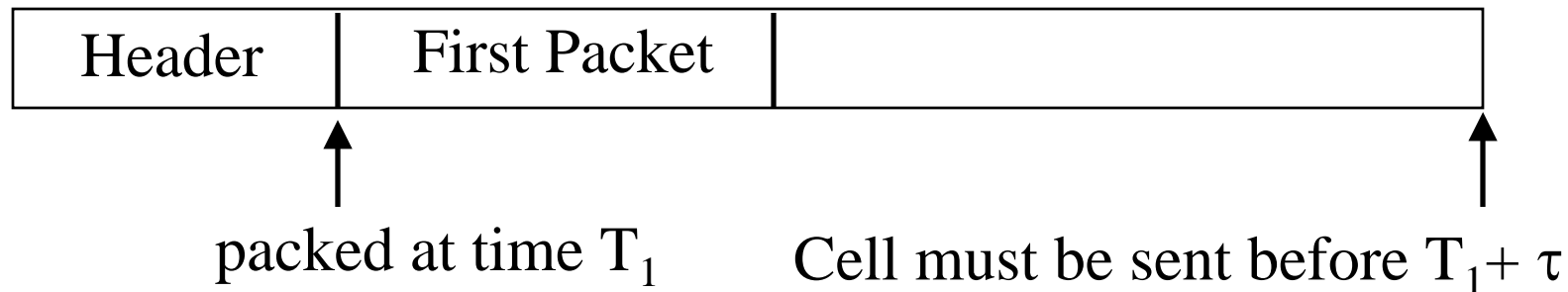
- ❑ In AAL2 voice trunking, voice packets from different sources are packed into one cell.
- ❑ **Problems:**
  - ❑ When a cell waits for other packets to arrive, the first packet may suffer prolonged delay.
  - ❑ If partially filled cells are sent, the link efficiency may become low.
- ❑ **Solution:** Choose an appropriate Timer\_CU value.

# Simulation Model



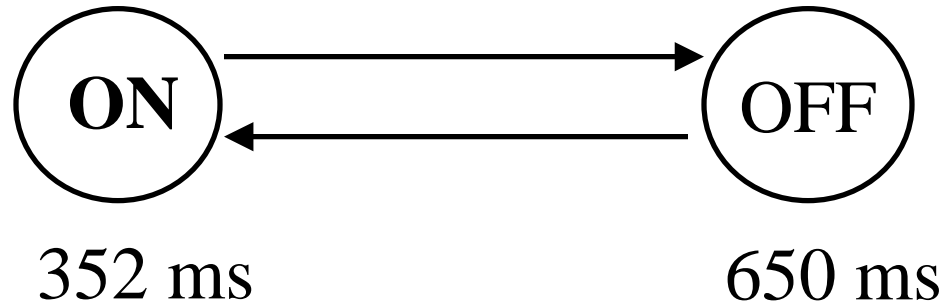
- ❑ Voice sources send G.723.1 packets to AAL2.
- ❑ AAL2 packs voice packets into cells and send them to the switch. Destination AAL2 will unpack the cell and dispatch each packet to its destination.
- ❑ AAL2 keeps a Timer\_CU to avoid prolonged delay.

# Timer\_CU



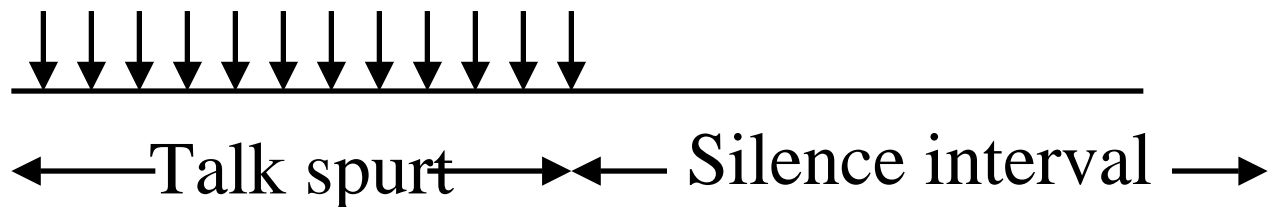
- ❑ Timer\_CU value  $\tau$  determines the time after which a cell has to be sent.
- ❑ Large Timer\_CU value leads to large packing delay.
- ❑ Small Timer\_CU value leads to more partial cells, and low link efficiency.

# Voice Model



- ❑ ON-OFF model
- ❑ Talk spurt: Exponential distribution, mean = 352 ms
- ❑ Silence: Exponential distribution, mean = 650 ms

# Packet Arrival Pattern

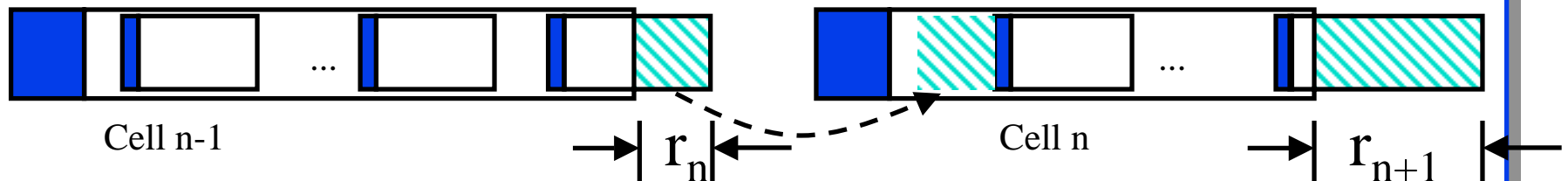


Arrival pattern in one cycle

- This is the arrival pattern from one source.
- Voice sources are independent.
- $R_i$  = Probability of receiving  $i$  packets within  $\tau$  ms.
- From packet arrival pattern, we can calculate  $R_0$ ,  $R_1$ ,  $R_{2+}$

# Markov Chain Analysis

- The packing process can be described with a Markov chain.
- Let  $r_n$  be the remainder length from cell  $n-1$ .
- Then  $r_{n+1}$  depends on  $r_n$  and the number of packets received in  $\tau$  ms.
- The transition matrix  $P$  depends on the packet receiving probabilities  $R_0, R_1, R_{2+}$ .



# Analysis Results

- $\pi = \pi P$  gives the stationary distribution  $\pi$ , the long run probability distribution of remainder length.
- From  $\pi$  and  $R_0, R_1, R_{2+}$ , we can calculate the average number of bytes in a cell, and then the average packing density.

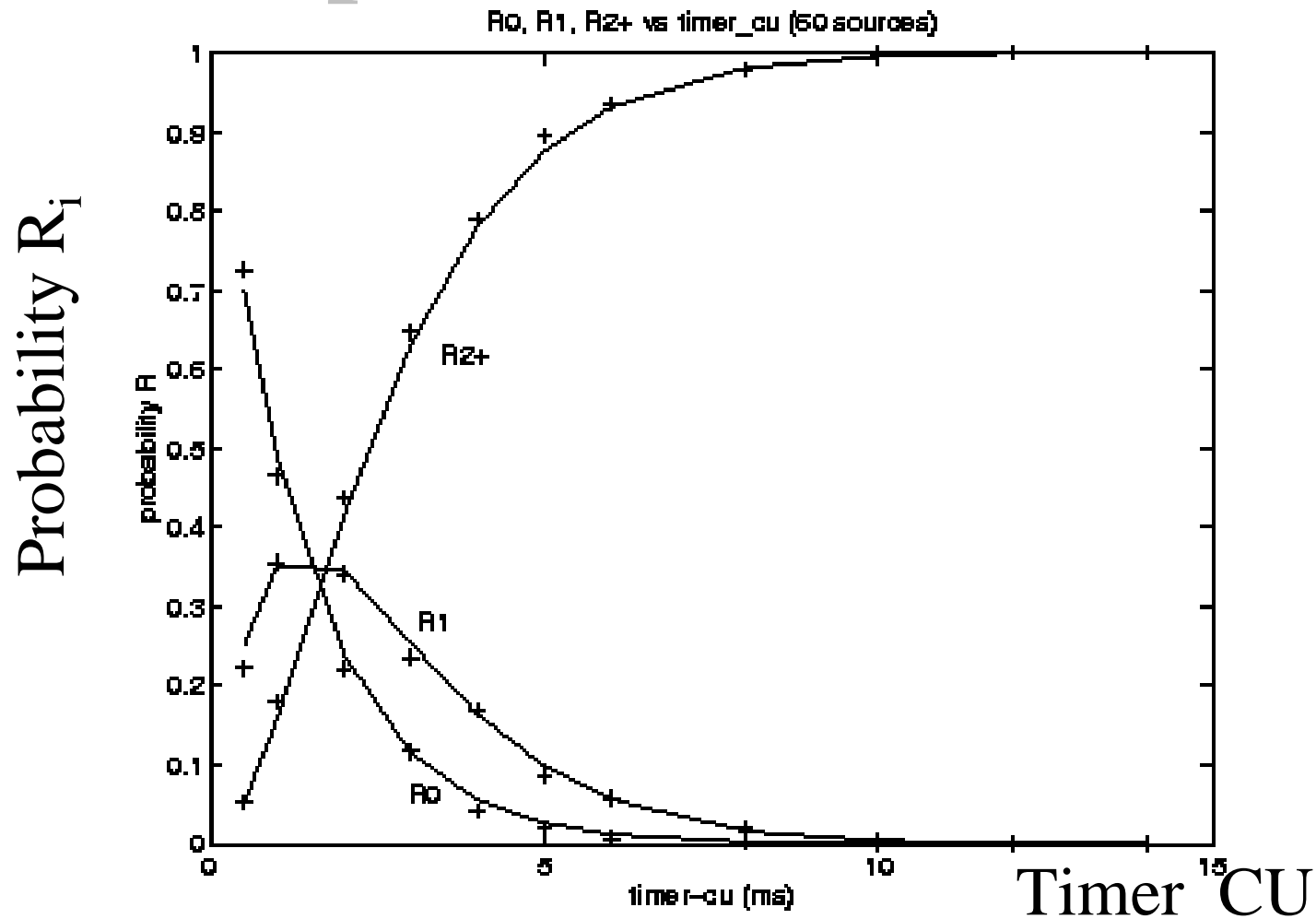
# Simulation

- ❑ To verify the analysis, we wrote a simulation program to implement the AAL2 packing process.
- ❑ The simulation generates talk spurts and silence intervals according to the ON-OFF model.
- ❑ Assume G.723.1 is used for voice encoding.
- ❑ Actual density is computed from the total number of voice bytes and the number of cells sent.
- ❑ The simulation results are summarized as follows.

# Simulation Results

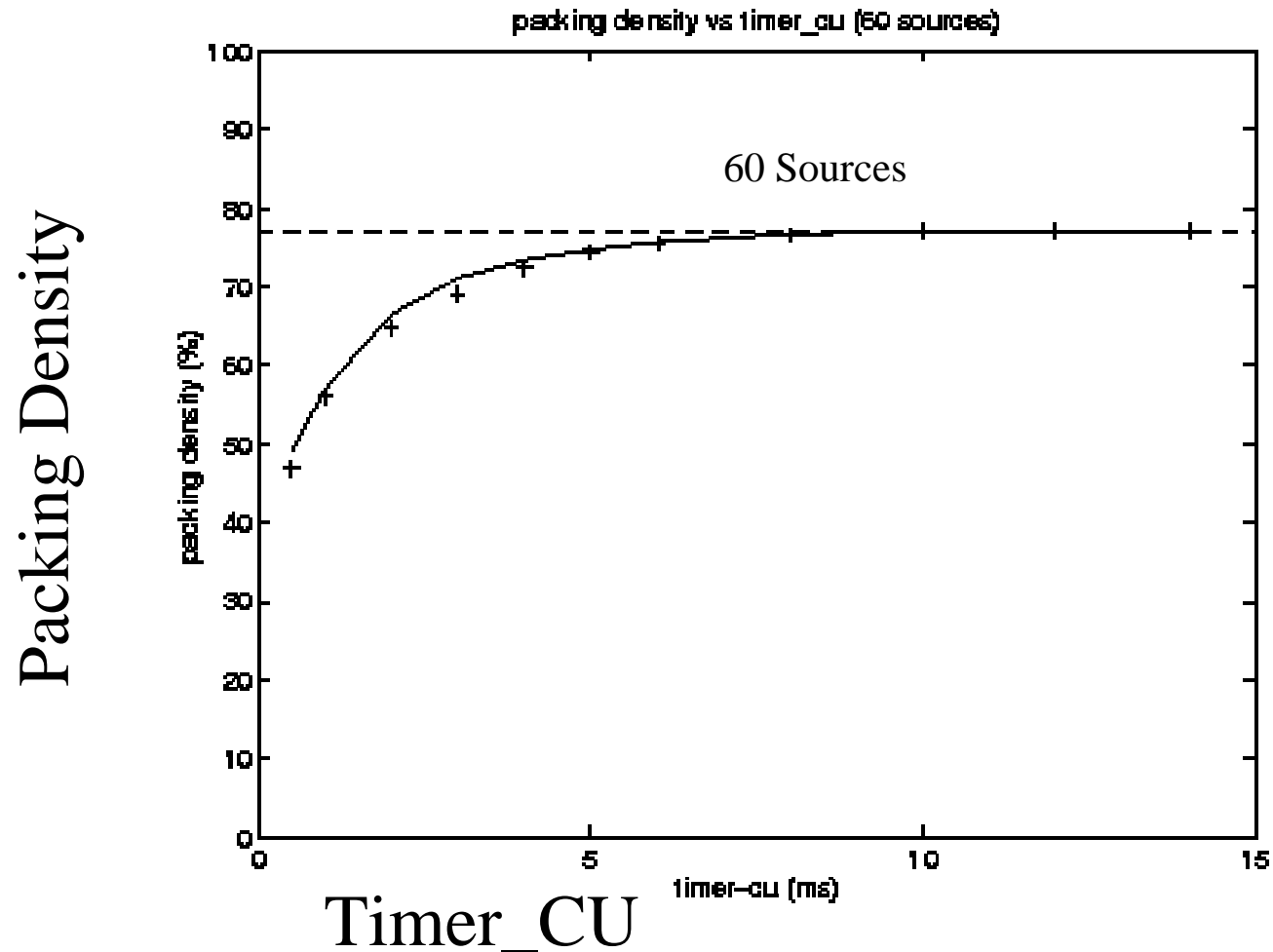
$\tau$	celles	Recv 0	Recv 1	Recv 2	Density %
0.5	5621	4079	1246	296	46.93
1	5028	2339	1787	902	56.00
2	4286	949	1462	1875	64.78
4	3705	154	626	2925	72.43
6	3587	26	206	3355	75.42
8	3470	8	66	3396	76.54
10	3716	0	10	3706	77.05
12	3779	0	0	3779	77.12

# Comparison: Probabilities



Analysis: solid lines, Simulation: “+”.

# Comparison: Packing Density

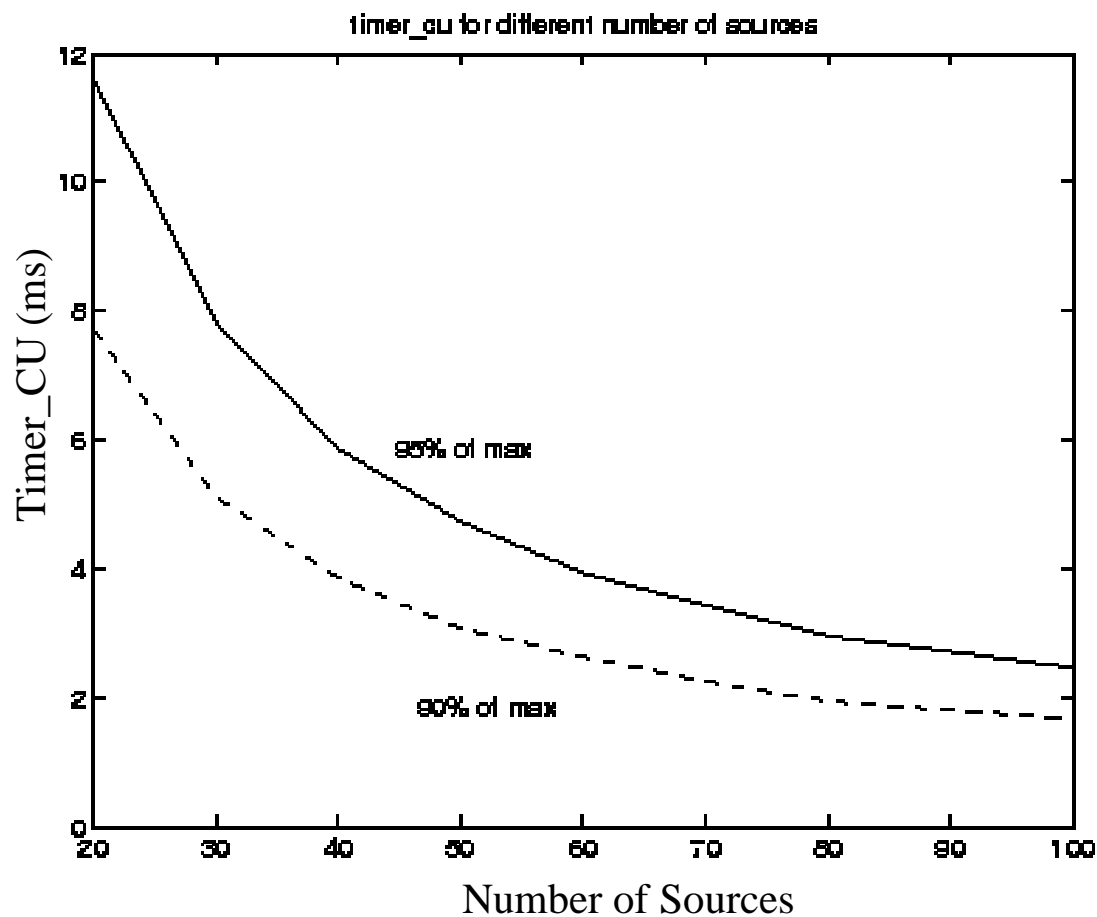


Analysis: solid lines, Simulation: “+”.

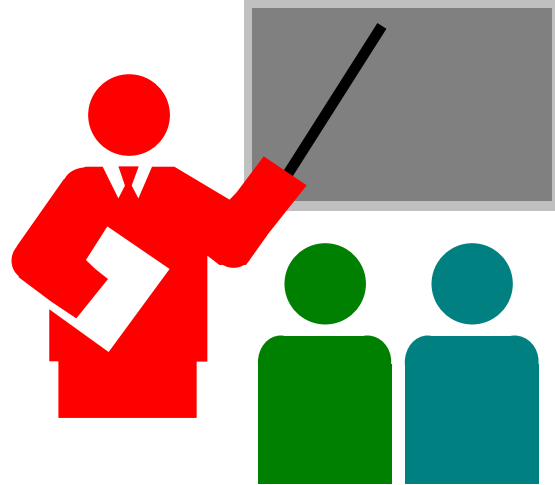
# Conclusion

- ❑ Packing density can be calculated from the number of voice sources and the given Timer\_CU value.
- ❑ The simulation results match the analytical results perfectly.
- ❑ Given the number of voice sources and the desired link efficiency, we can calculate the appropriate Timer\_CU value.
- ❑ The next slide gives the Timer\_CU values to achieve 90% and 95% of the maximum link efficiency for different number of voice sources.

# Timer\_CU values for Different Number of Users



# Summary



- ❑ The Timer\_CU value can significantly affect link efficiency.
- ❑ It should be set according to the number of sources and delay requirement.
- ❑ This contribution gives an algorithm to calculate a Timer\_CU value to achieve desired link efficiency.