Performance Analysis of the IEEE 802.11s Power Save Mode for One Peer Link Operation.

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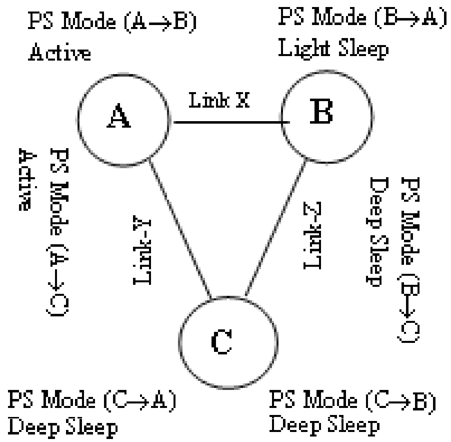
Overview of 802.11s PSM

- A new Technique called Link Specific Power Save Mode (PSM) is Proposed. PS Modes are : **Light Sleep, Deep Sleep and Active Mode**.
- Distinguishable Features: **a)** STA Only Transmits to its Peer STAs. **b)** A STA can Maintain Different PSM to its Different Link or Peer at the Same time.
- A new Peer Service Period (PSP) Mechanism is also Introduced in the Upcoming IEEE 802.11s Amendment.

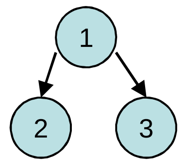


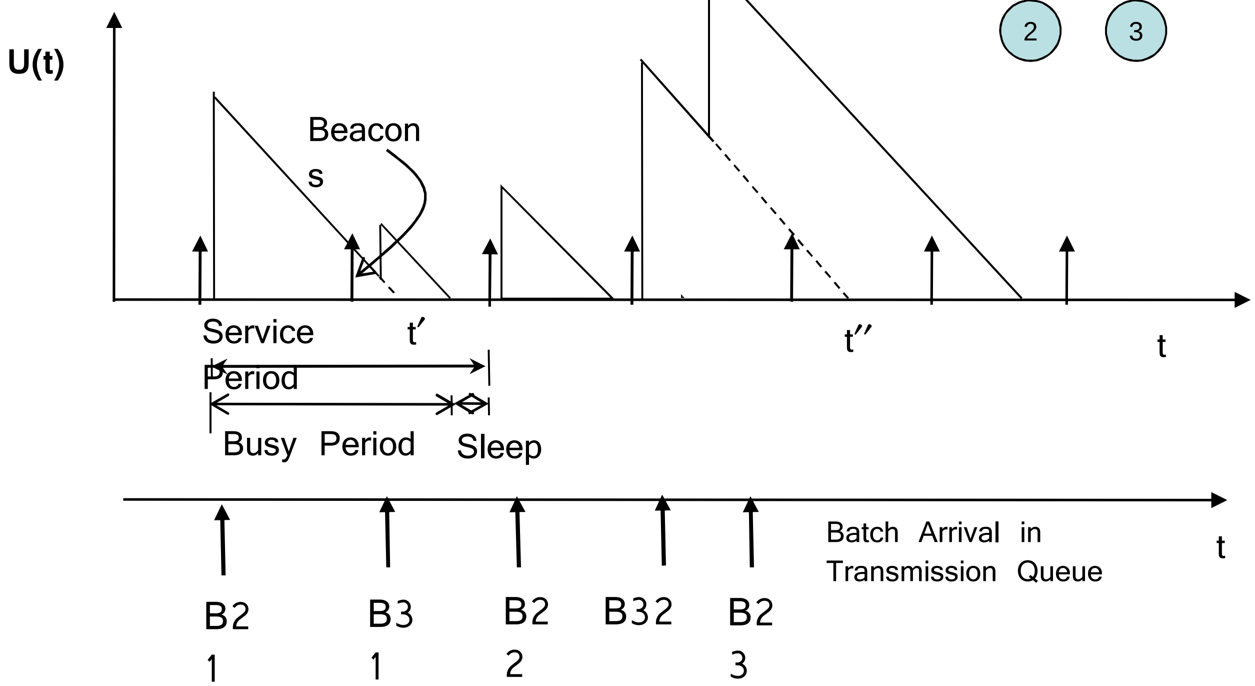
Summary of the Work

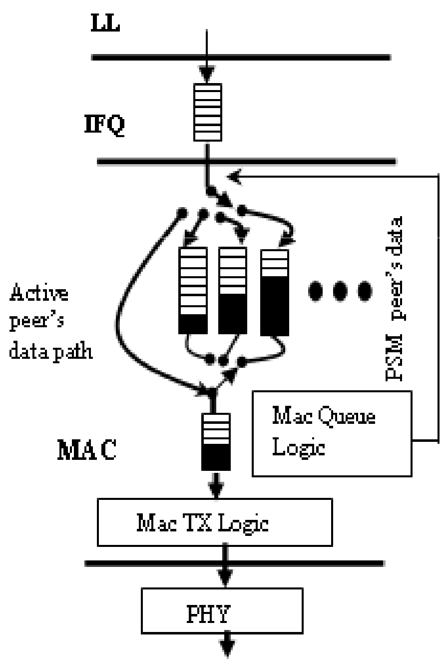
- IEEE 802.11s PSM Functionalities, such as, Beacon Management, PSP Protocol, PSM Efficient Queue as well as Peer-Specific-Buffers on Top of the Queue are Implemented in the **Network Simulator NS2**.
- Based on Discrete Time Discrete State Markov Chain, Several **Stochastic Models** are Developed to Validate the Simulation Results.

Implemented Batch Scheduling Method

- At the Begininig of each PSP, a **Bunch of Packets or Batch** to be Delivered, are Transferred from the **Temporary Buffer to The MAC Transmission Queue.**







Batch arrival process in STA1's queue **for two peers**. B21 means, this batch is the first batch for STA2. Similarly B32 is the second batch for STA3.

Stochastic Model

- Based on Discrete Time Discrete State Markov Chain, Several Stochastic Models are Developed to Validate the Simulation Results.
- It is Found that the Analytical Results Agree with the Simulation Results.
- The Following Slides Show both Analytical and Simulation Results for One Peer Link PSM Operation.

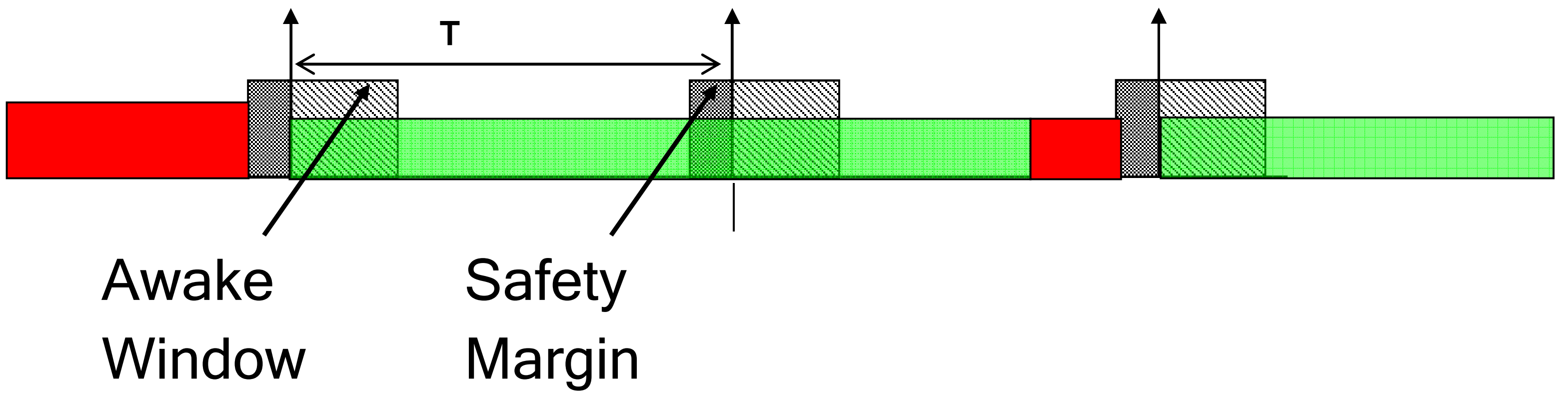
Scenario at a Glance

- Two PSM STAs.
- Packet Size 1KByte
- Traffic is Poisson Distributed.
- UDP Packet.
- Transmitter STA Operates in Deep Sleep Mode for the Link.
- Receiver STA Operates in Light Sleep Mode for the Link.
- Access Technique is DCF

PSM Related Parameters

- Receiver Initiated PSP.
- Beacon Period =102.4 ms.
- Awake Window = 5ms.
- Safety Margin (to Wake up Δt ms before TBTT) = 0.1024 ms.
- Average No. of Packet Possible to Transfer in One Beacon Period

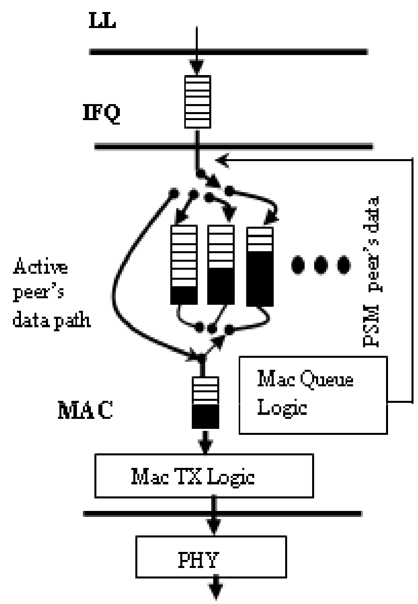
$$\cong \left\lceil \frac{Beacon\ Period}{Average\ TX\ Time\ of\ a\ Packet} \right\rceil \cong 65$$

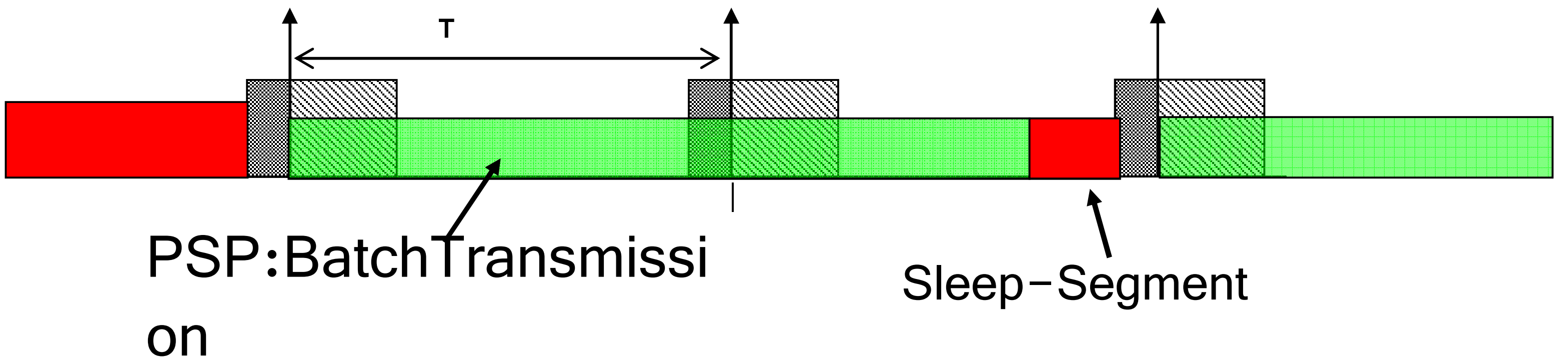


Results

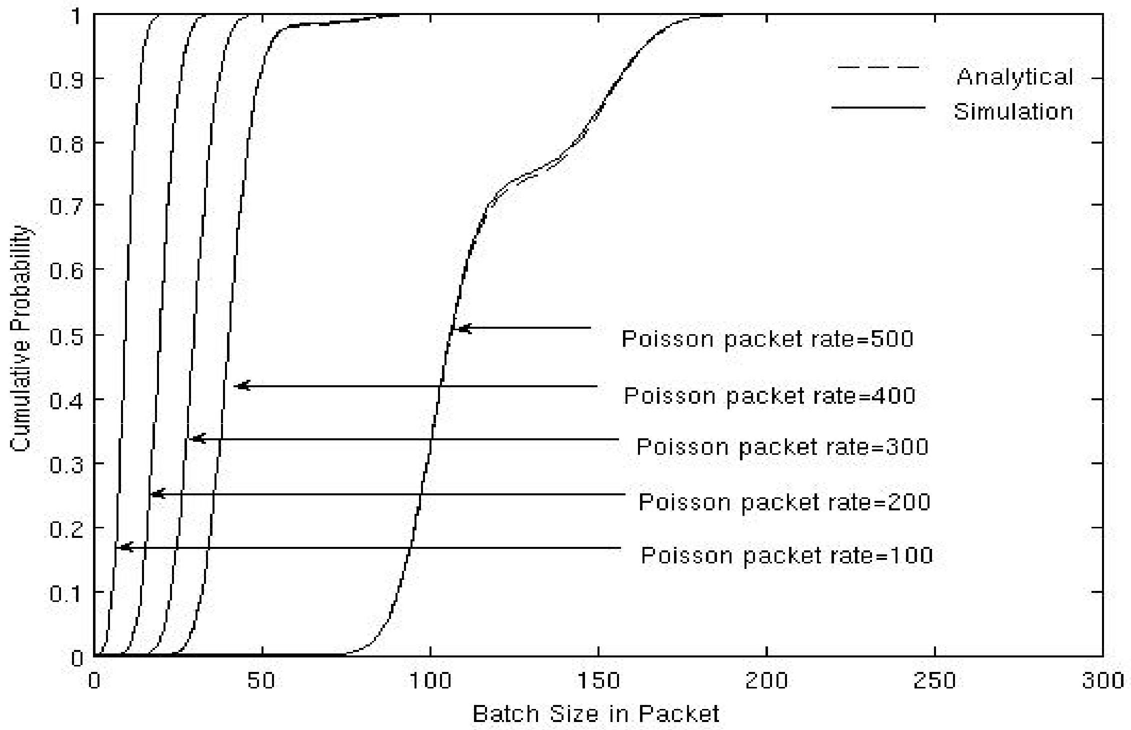
1. Batch Size Distribution

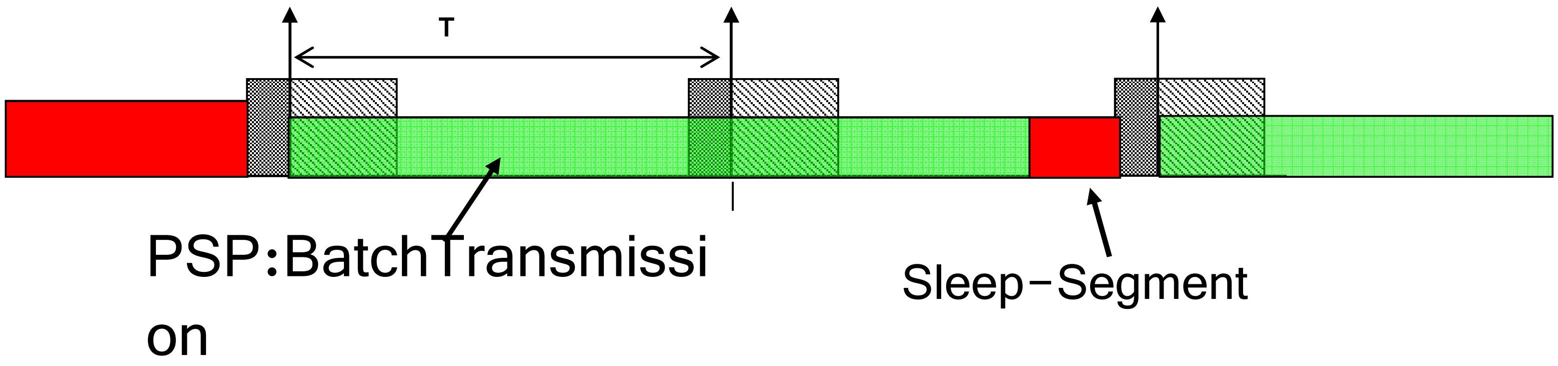
- At the Begininig of each PSP, a Bunch of Packets or Batch to be Delivered are Transferred from the Temporary Buffer to The MAC Transmission Queue.
- Current Batch Size only Depends on the Previous Batch Size or more specifically the Previous Batch Transmission Time.





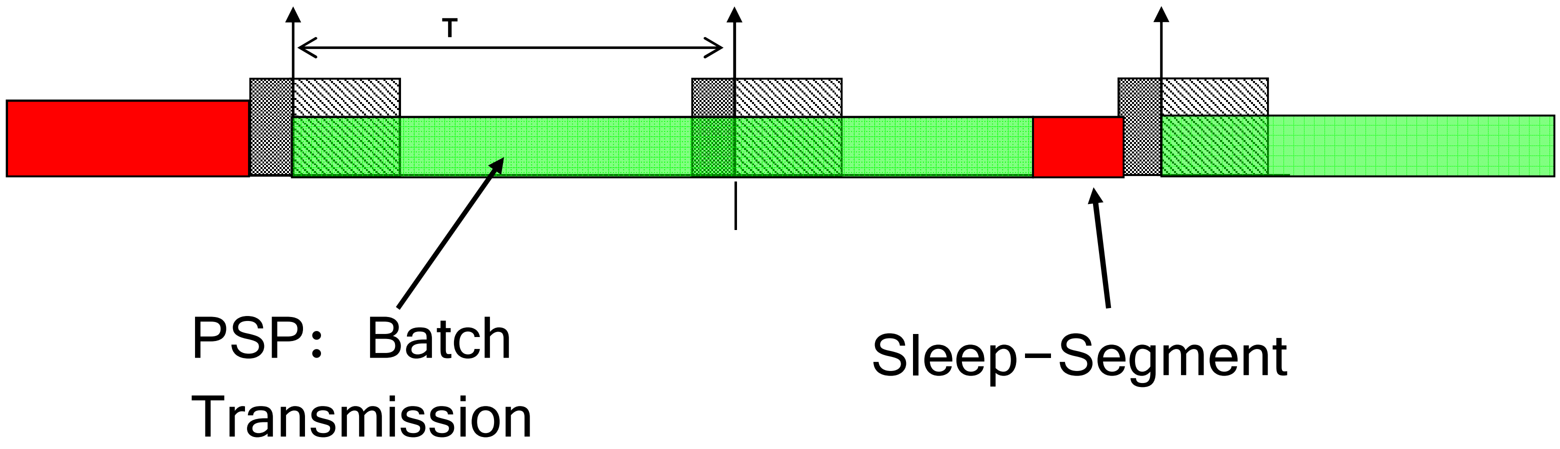
Batch Size Distribution



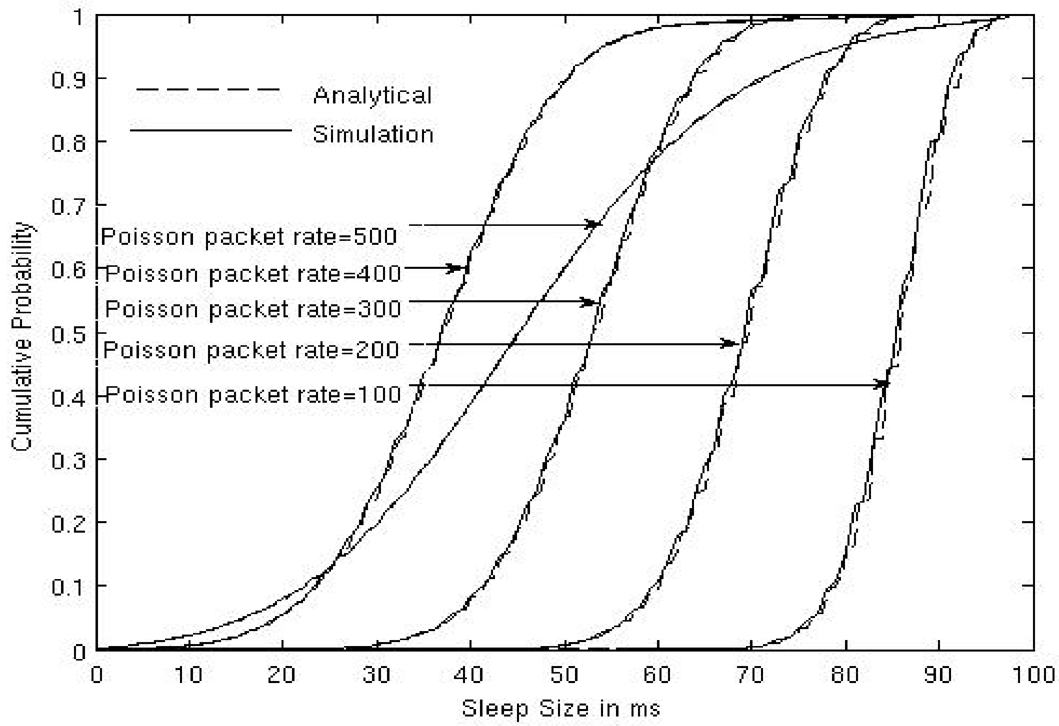


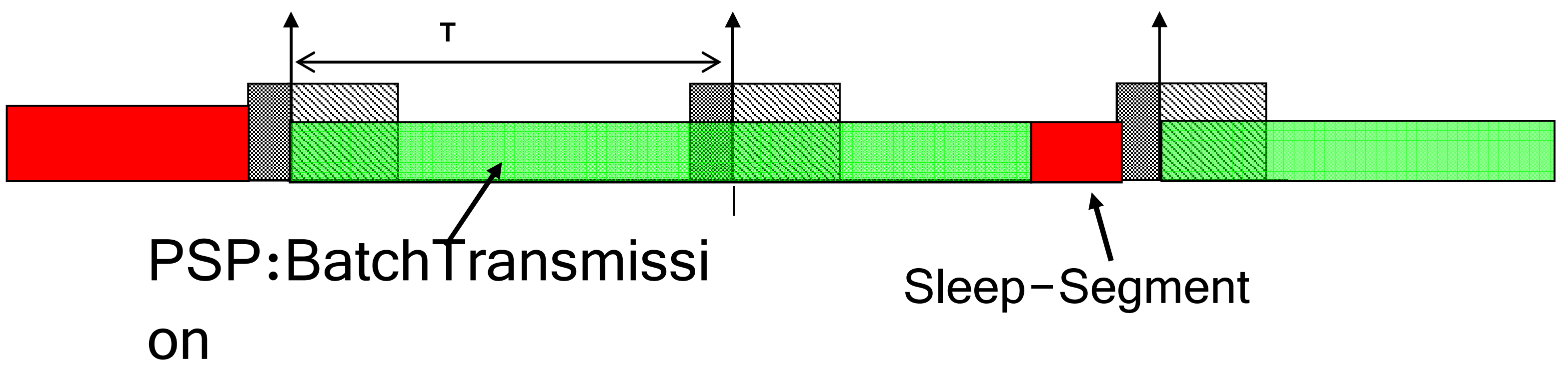
2. Sleep Time Distribution

- Only after a Successful PSP (Receiving ACK of PSP-end- Trigger) ,Transmitter Goes to Sleep if the Remaining Time for the Next Wakeup is Greater than Zero.
- Non Efficient Switching (in case of very Small Sleep) are not Avoided in this Prticular Experiment.



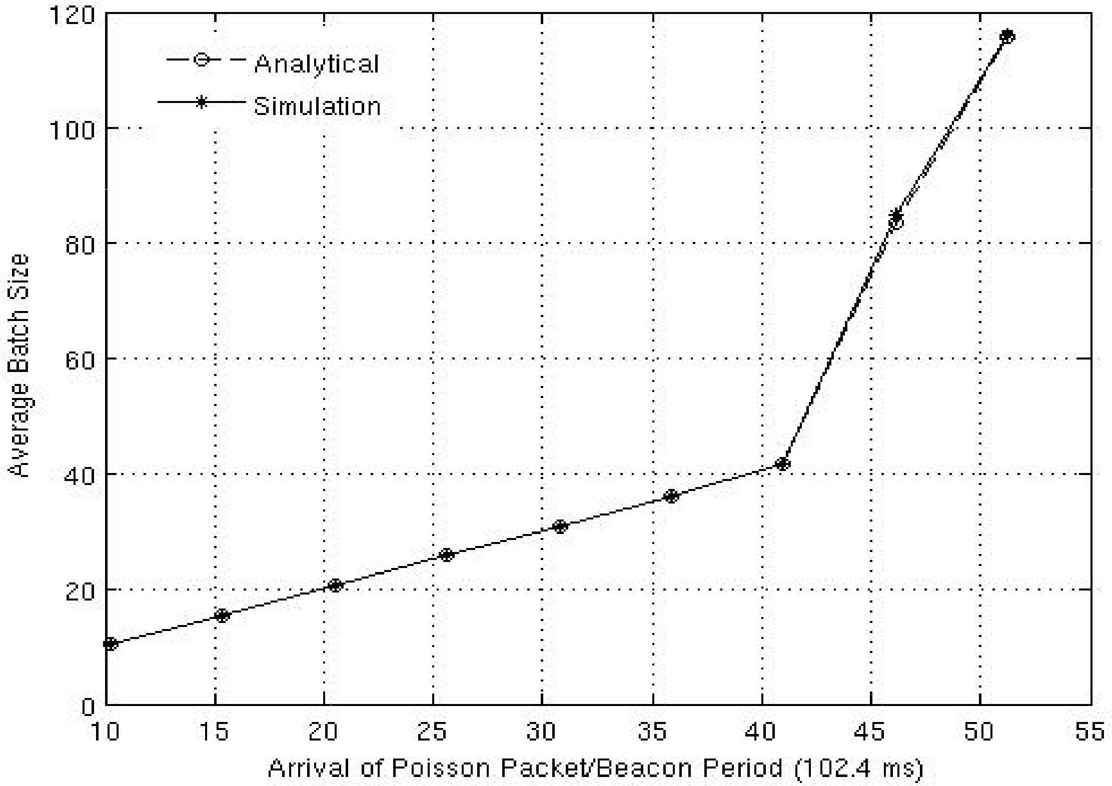
Sleep Time Distribution





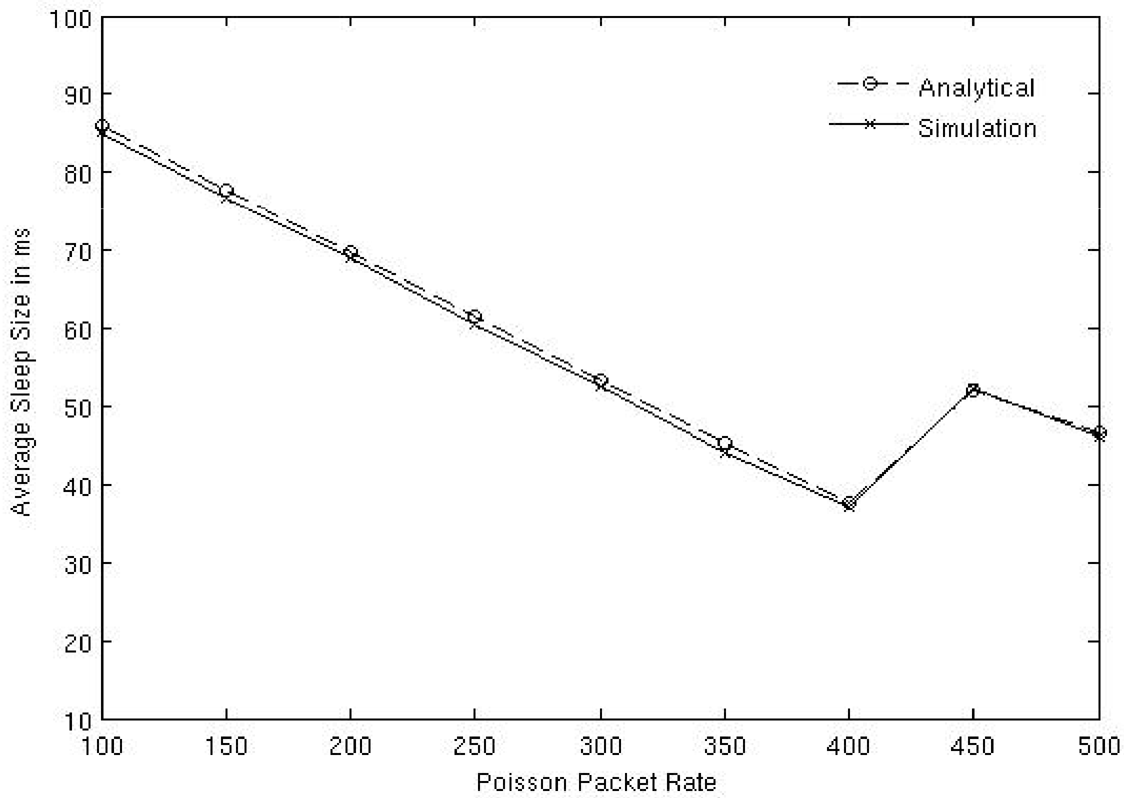
3. Average Batch Size

- Buffered Packets (Batch) are Tranfferred to the MAC Transmission Queue at the Begining of each PSP.



4. Average Sleep Time

- After Each Successful Batch Transmission (End of a Successful PSP), STA Goes to Sleep If the Remaining Time for the Next Wake Up is Greater Than Zero.



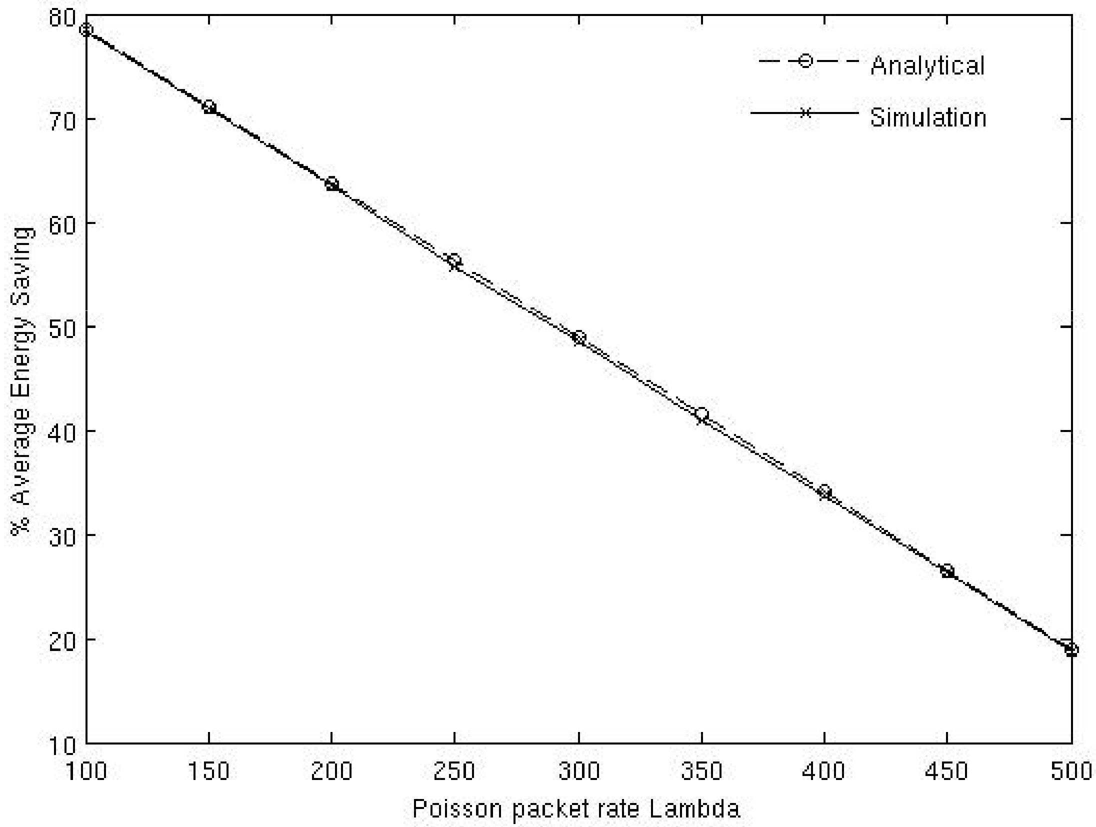
5. Average Energy Saving Compared to Active Mode Operation

- Percentage of Average Energy Saving

$$= \frac{\begin{bmatrix} (Energy\ requires\ to\ Deliver\ an\ Average\ size\ Batch\ in\ Active\ Mode) \\ -(Energy\ requires\ to\ Deliver\ an\ Average\ size\ Batch\ in\ PSM\ Mode) \end{bmatrix}}{(Energy\ requires\ to\ Deliver\ an\ Average\ Batch\ in\ Active\ Mode)}$$

- In the Above Calculation, Energy Consumption for Switching has not yet Considered.

Percentage of Average Energy Saving

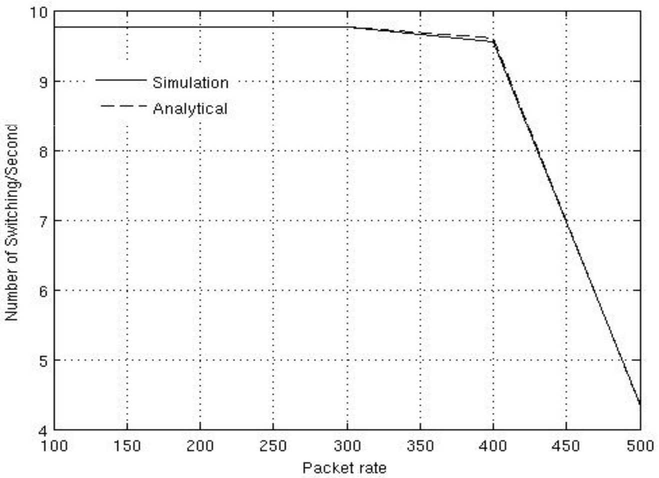


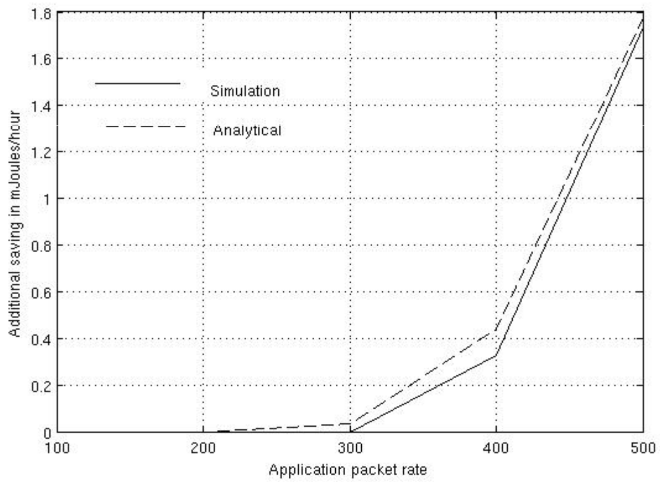
It is Assumed,
TX Power,RX Power,Idle State Power=750mw.

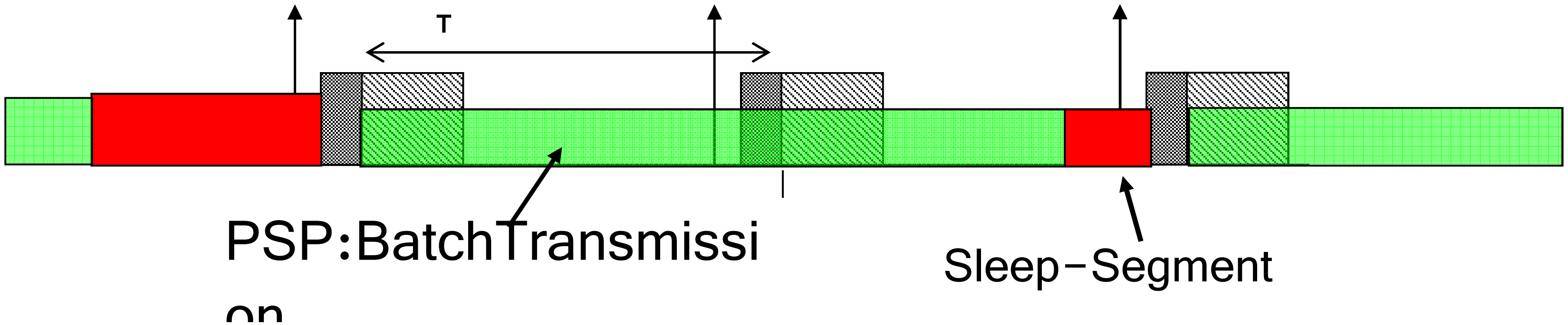
Sleep State Dissipated Power=50mw.

6. Switching Rate & Smart Switching

- Transition from Sleep State to Idle State.
- This Transition Time (Approx. 250μs) could Consume Twice the Energy Consumed in Idle State Operation. (Suppose 0.422mJ/Switching).

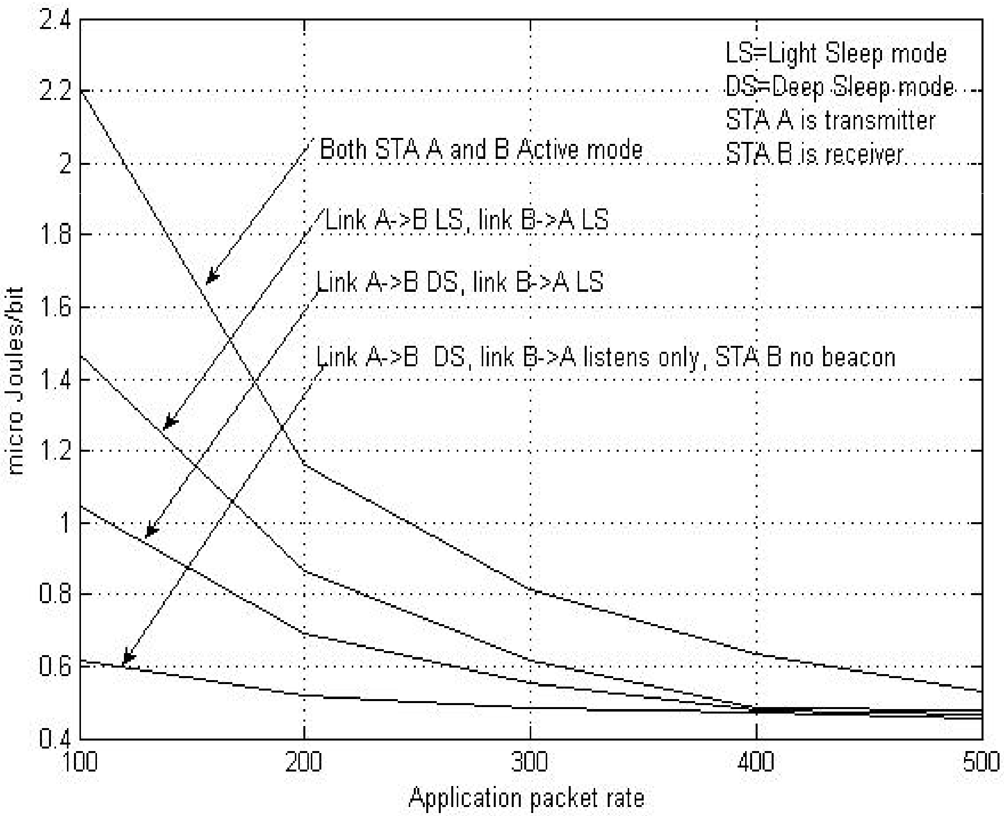






7. Energy Expenditure Per Bit

- Amount of Expended Energy in the Network Depends on the Link Specific Power Modes.



A Realistic Energy Model is Used Here:

- TX=1.327 W
- RX=0.967 W
- Idle=0.844 W
- Doze=0.066 W
- Switching=0.422mJ

Conclusion

- Amount of Energy Expended in the Network Depends on the Link Specific Power Modes of the STAs.
- Percentage of Energy Saving Decreases with Traffic Rate.
- Number of Switching is an Important Factor in Energy Efficient Operation. Transition Time for Switching could Consume Twice the Energy Consumed in Idle State Operation.
- Avoiding Very Narrow Sleep Could Save Some Extra Energy by Avoiding Switching Loss. (A Kind of Smart Switching)
- Smart Switching Could Save Large Amount of Energy in a Deterministic Traffic Load.