Power Saving Access Points for IEEE 802.11 Wireless Network Infrastructure

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Introduction

- Multihop communications will be increasingly used for access point range extension and coverage enhancement.
- This paper present a design for an IEEE 802.11-based power saving access point (PSAP), intended for use in multihop battery and solar/battery powered applications.

Power Saving IEEE 802.11 Access Points(PSAPs)

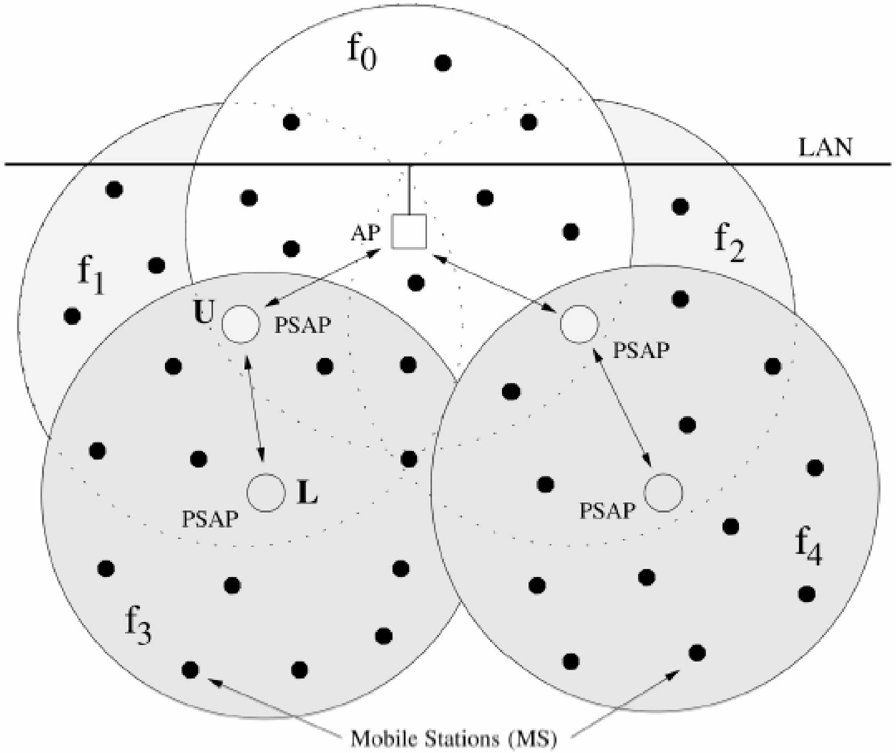


Fig. 1. Power saving wireless LAN example.

Power Saving IEEE 802.11 Access Points(PSAPs)

- Each PSAP provides a HOME channel (or H-channel) and acts as an access point to those MSs within its coverage range.
- In addition, each PSAP has a RELAY channel (or R-channel), which it uses to forward/download traffic to/from its parent AP or PSAP.
- The design is very flexible in that the R and H-channels for a particular PSAP can use the same or different IEEE 802.11 frequencies.

PSAP operation

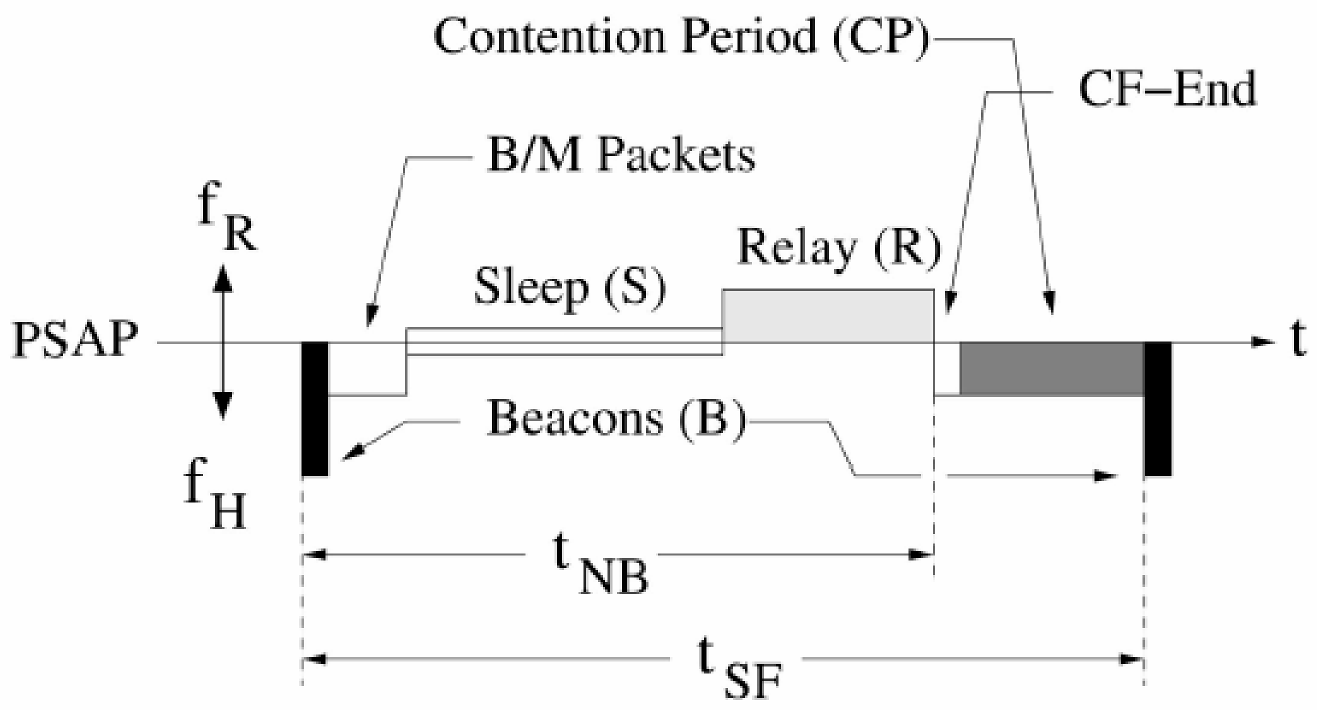


Fig. 2. PSAP operation.

PSAP Frame Timing

- HOME frequency, f_H
- RELAY frequency, f_R
- the PSAP establishes a superframe of length t_{SF}
- The basic PSAP time line consists of three subframes.
  - Sleep/Doze or S subframe,
  - The Relay or R subframe,
  - A contention period or CP subframe

Frame Layout

- The simplest design is to have a single sleep and relay subframe.
  - SR frame layout.
  - RS frame layout.
- A more complex combination of the two.
  - SRS frame layout.

SR Frame Layout

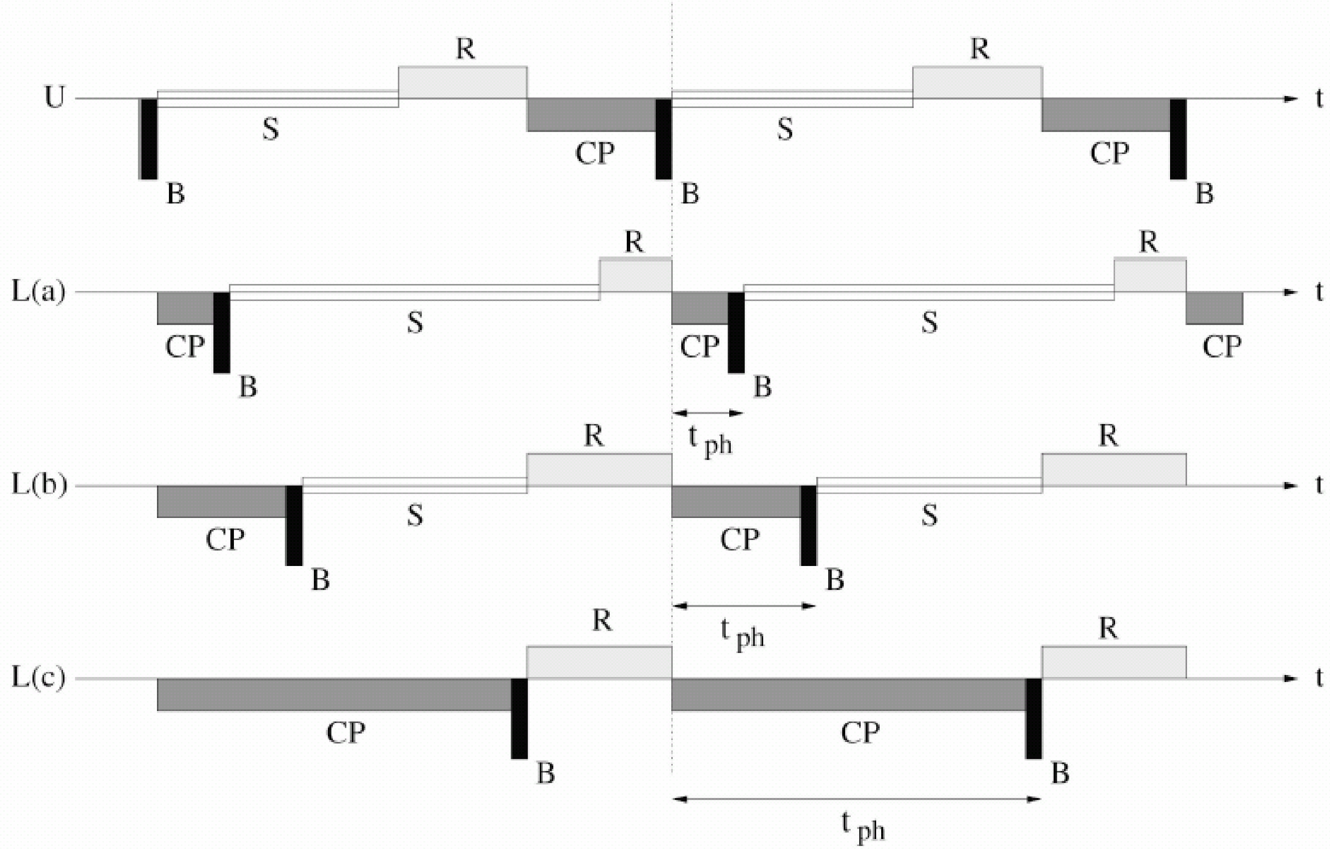
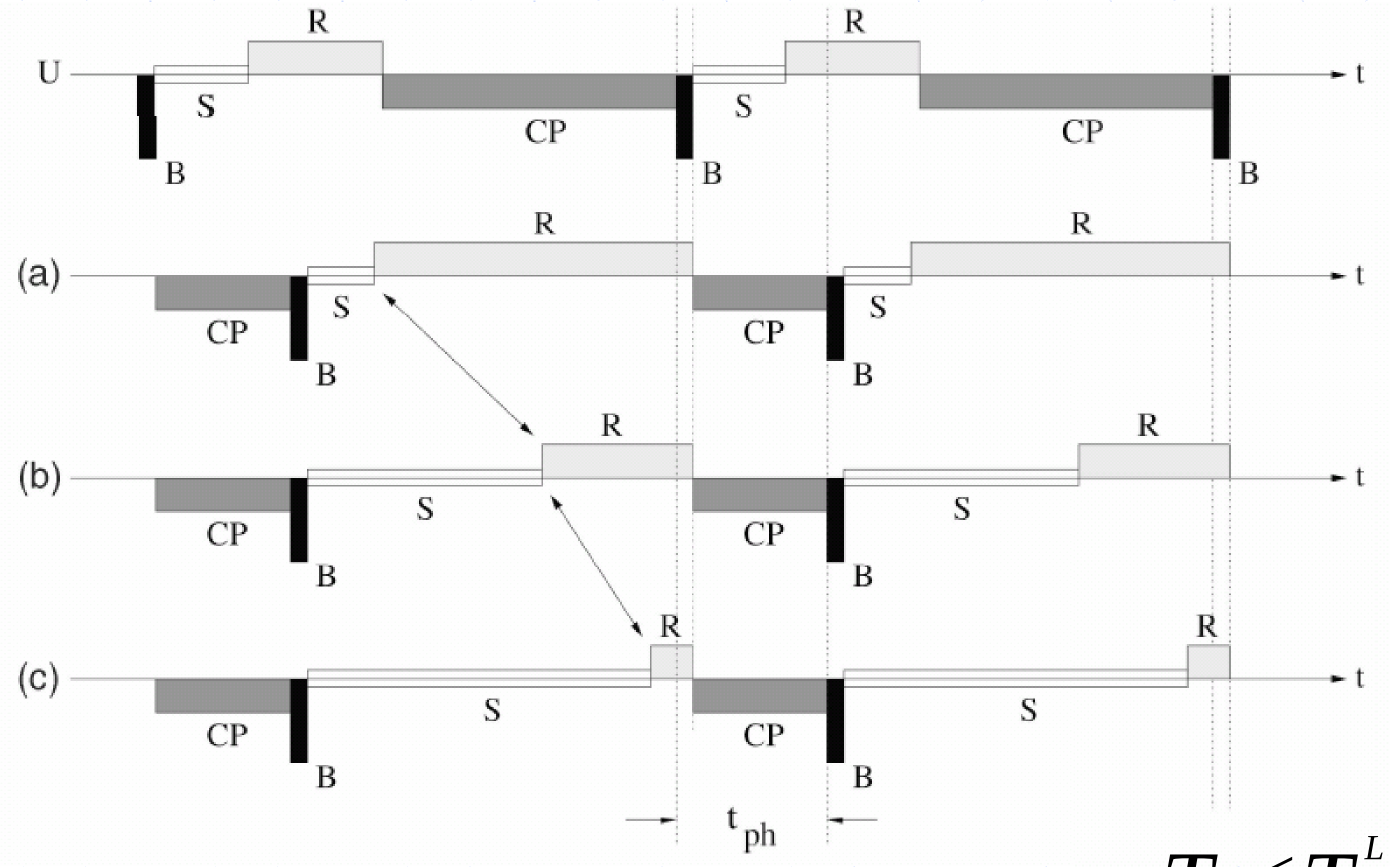


Fig. 3. SR frame layout timeline examples with different beacon positions.

SR Frame Layout

- Duration of the CP interval for U T_{CP}^{U}
  - The R subframe should never exceed the duration of the upper layer CP subframe,
  - And the end of the R subframe must always overlap with the upper level beacon transmission.
- When using the SR frame layout, once the location of the L-beacon is chosen, then the value of T_{CP}^{U} has been fixed.

SR Frame Layout



$$T_B \leq T_R^L \leq T_{CP}^U$$

Fig. 4. SR frame movable boundary timeline, fixed CP subframe.

RS Frame Layout

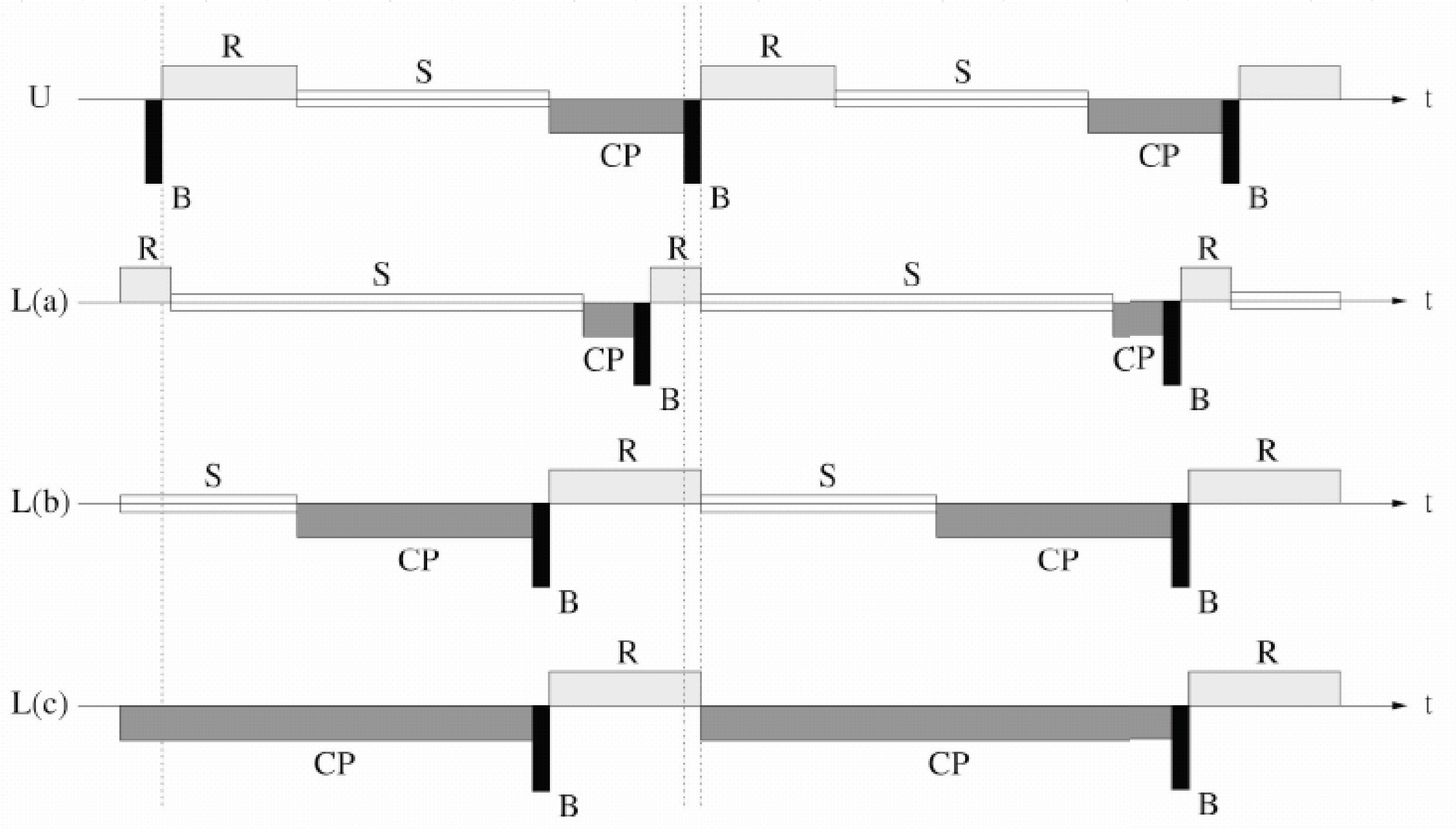
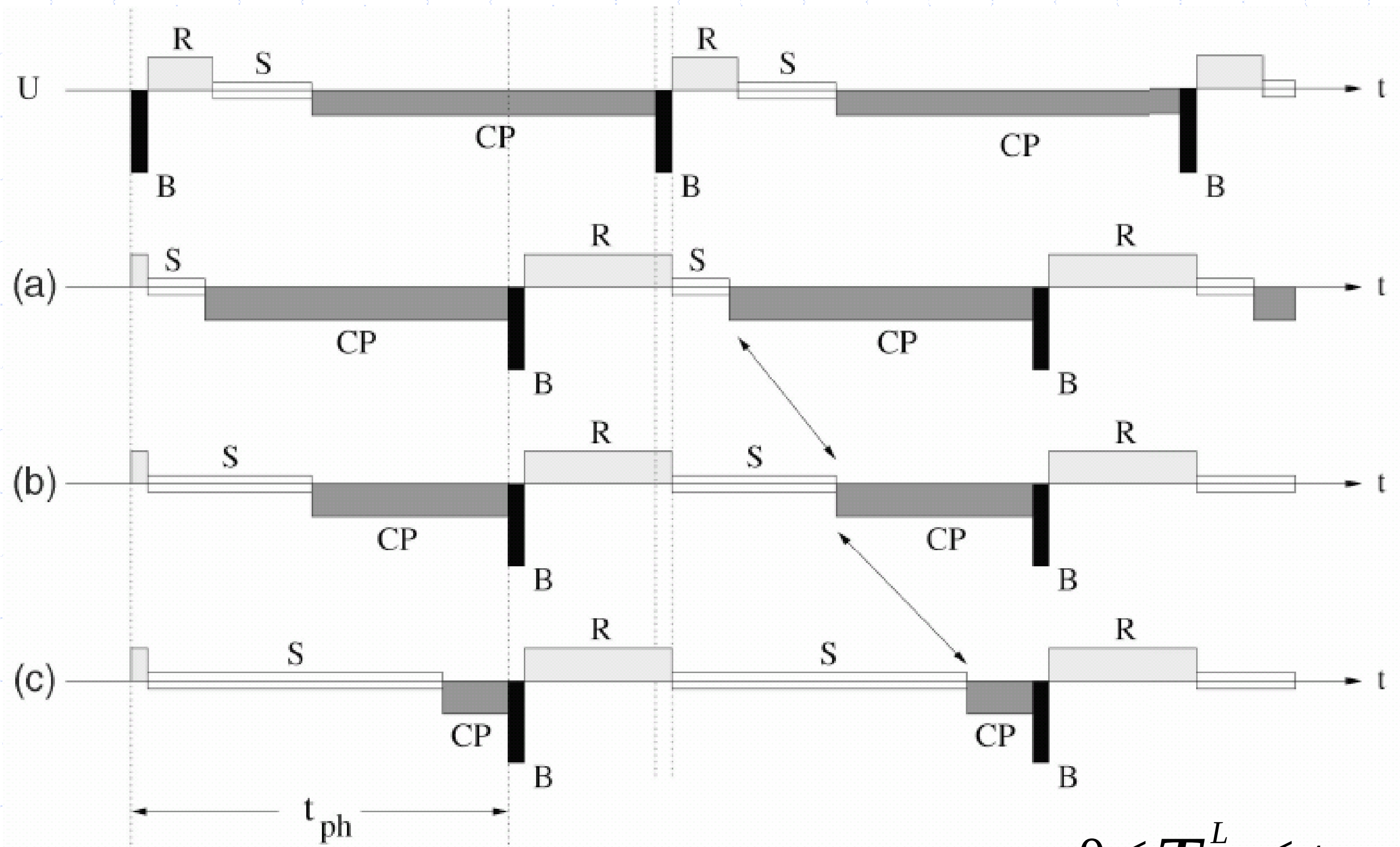


Fig. 5. RS frame layout timeline examples with different beacon positions.

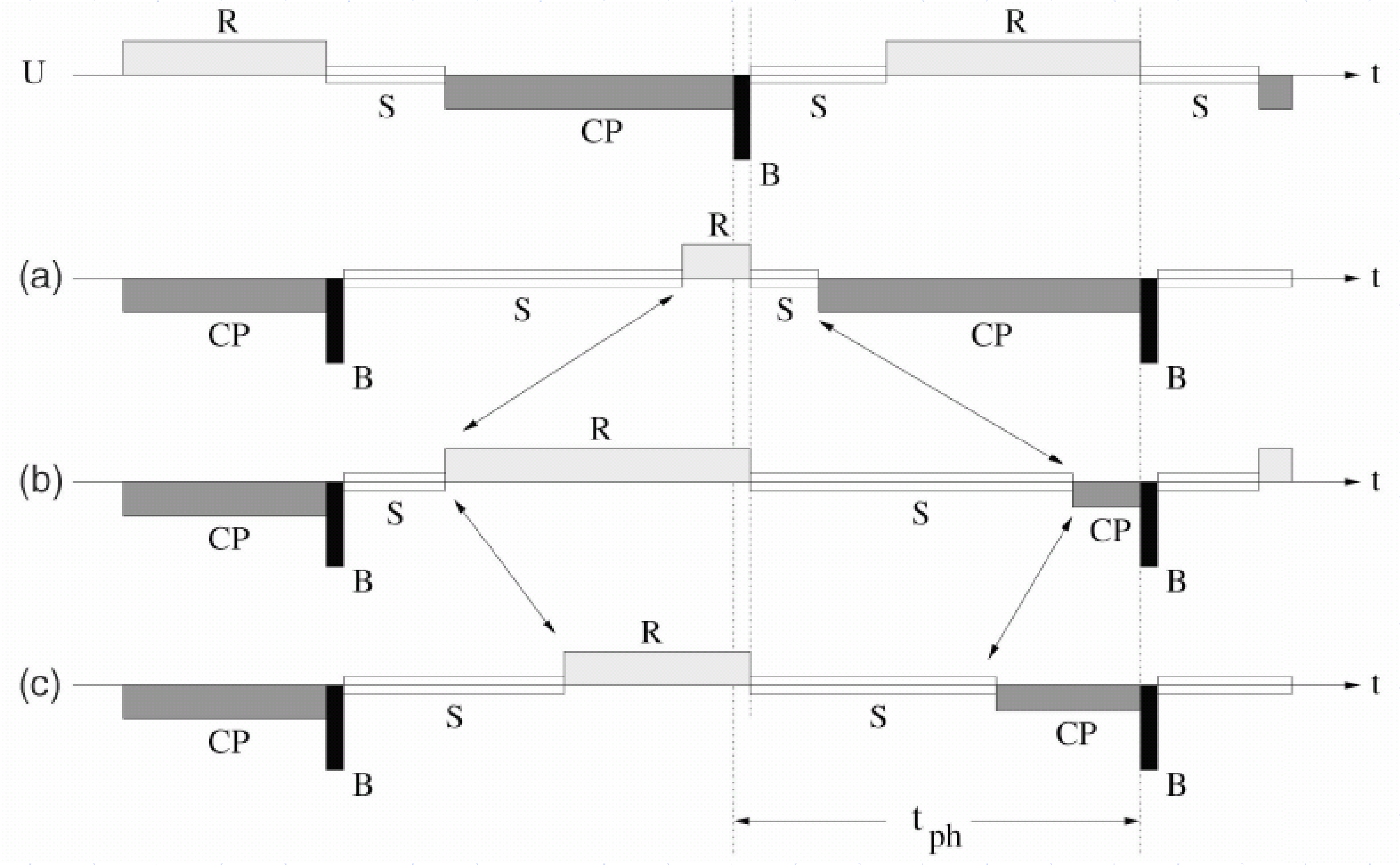
RS Frame Layout



$$0 \le T_{CP}^{L} \le t_{SF} - T_{R}^{L} - T_{B}$$

RS frame movable boundary timeline, fixed R subframe.

SRS Frame Layout



SRS frame timeline layout showing movable boundaries.

SRS Frame Layout

$$\max(T_{CP}^{L}) = t_{ph} - T_{B},$$

$$\max(T_{R}^{L}) \leq T_{CP}^{U},$$

$$0 \leq T_{CP}^{L} \leq \max(T_{CP}^{L}),$$

$$0 \leq T_{R}^{L} \leq \max(T_{R}^{L}).$$

PSAP Design And Capacity Allocation

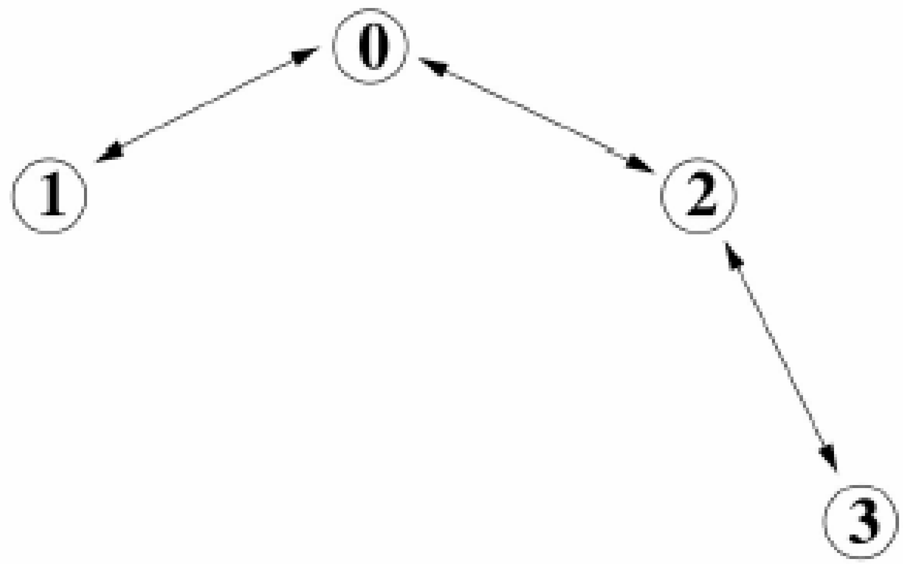
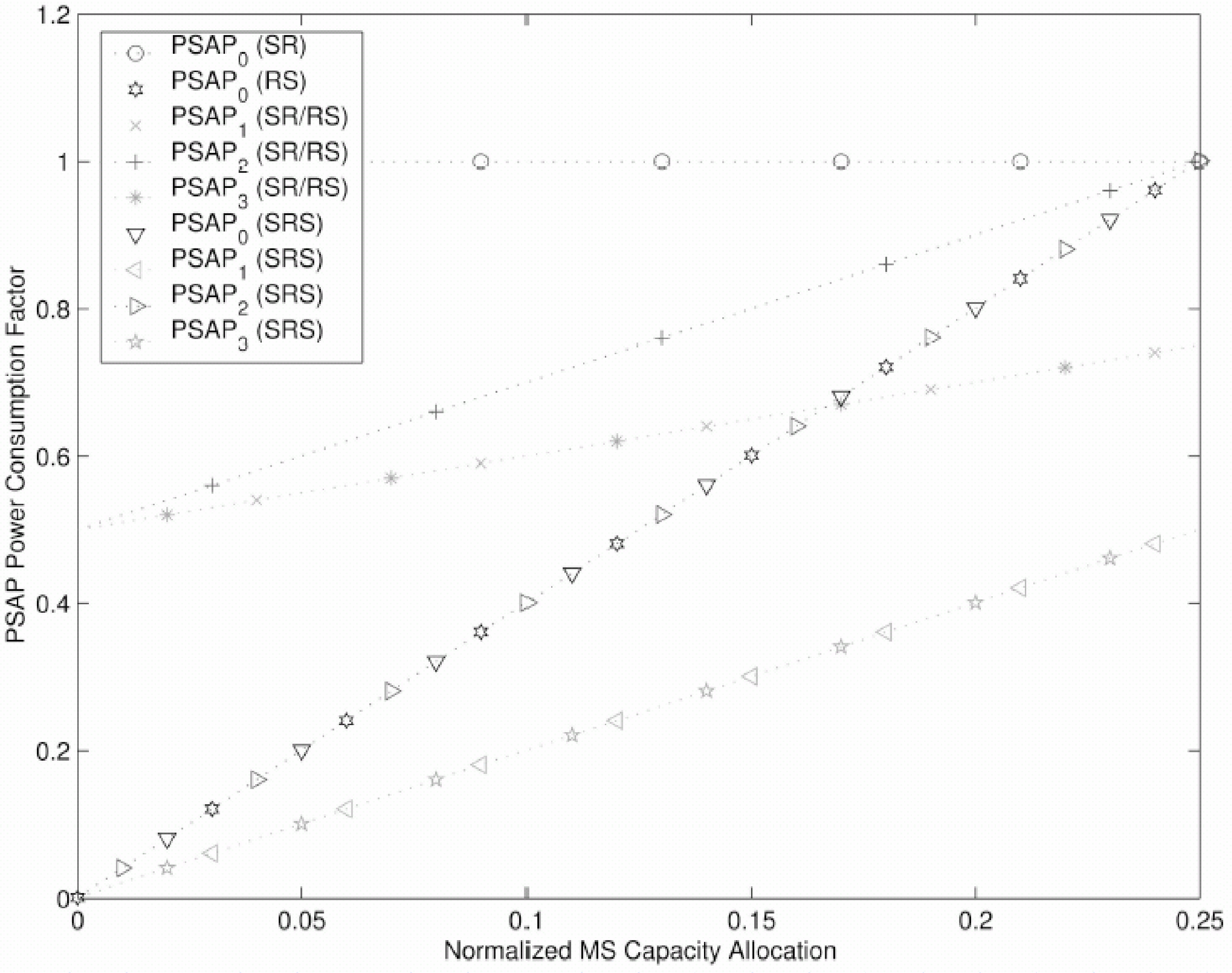
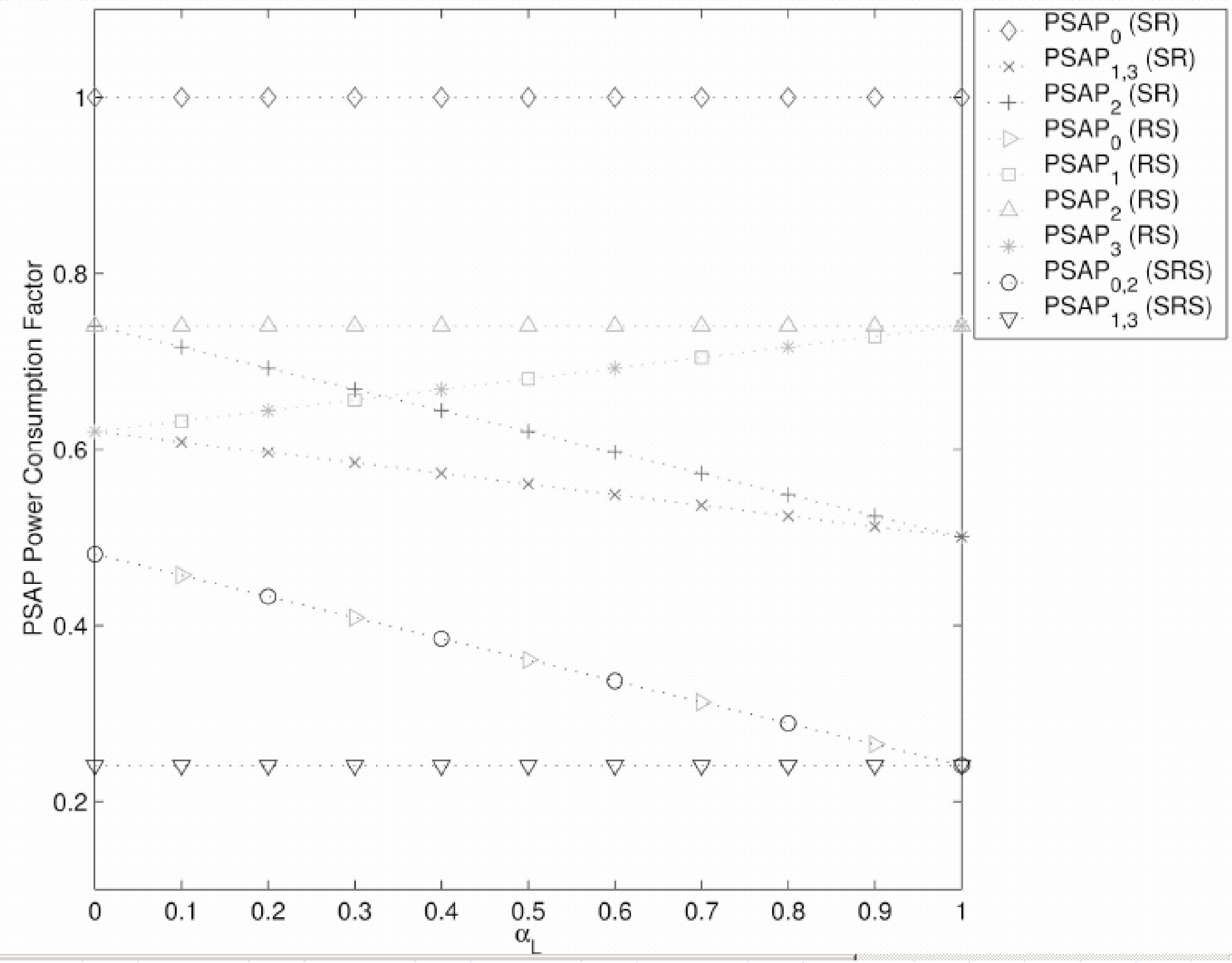


Fig. 8. Example PSAP network.

Power consumption factors for access network application.



Power consumption factors for varying traffic locality



Performance

TABLE 1
Default Simulation Parameters

Parameter	Value
AP beacon interval	100 ms
WLAN transmission rate	11 Mbps
Number of data stations per PSAP, N_s	20
Data packet payload	200-500 bytes (uniformly distributed)
ACK packet payload	14 bytes
Power consumption in LISTEN mode	500 mW
Power consumption in TRANSMIT mode	750 mW
Power consumption in RECEIVE mode	500 mW
Power consumption in DOZE mode	2 mW

Performance

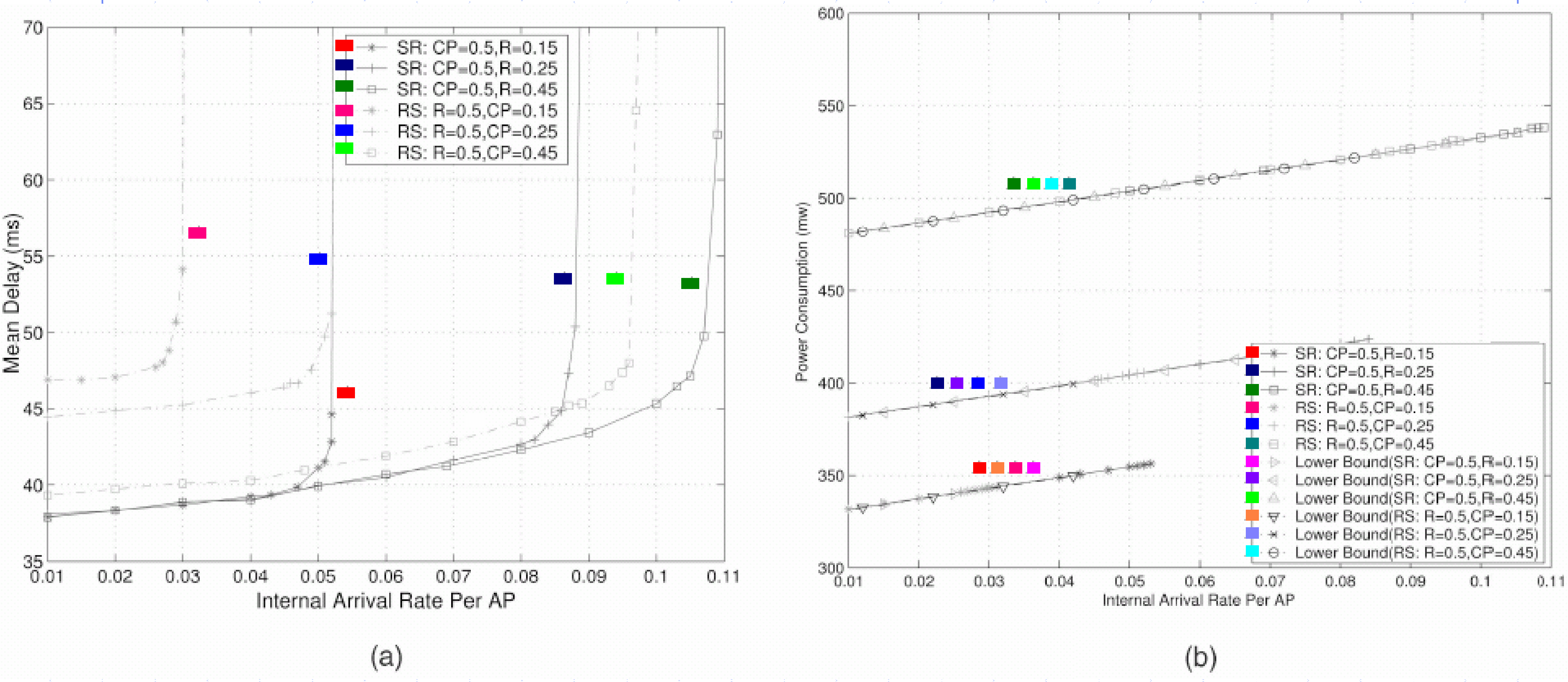


Fig. 11. Comparison of SR and RS. (a) Mean delay. (b) Mean power consumption

Performance

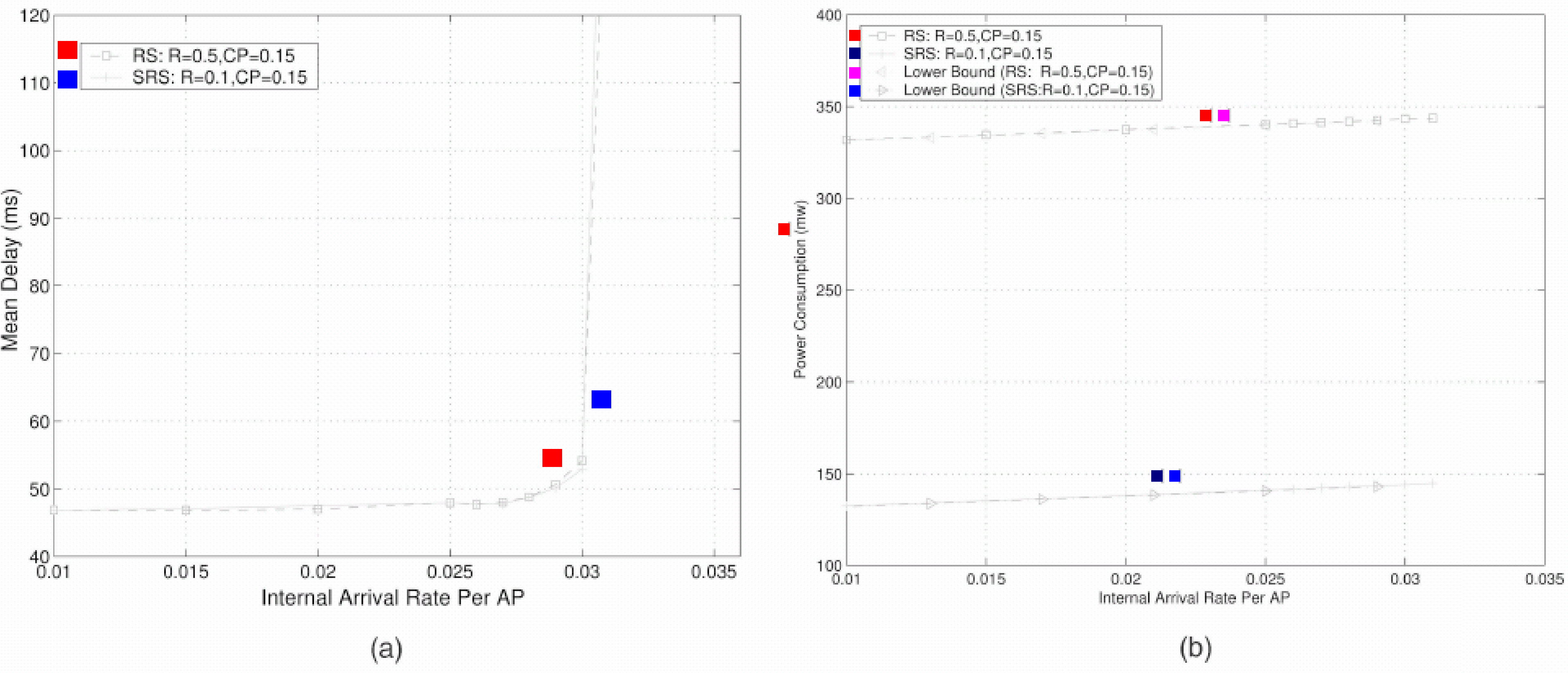


Fig. 12. Comparison of SRS and RS. (a) Mean delay. (b) Mean power consumption.

Performance

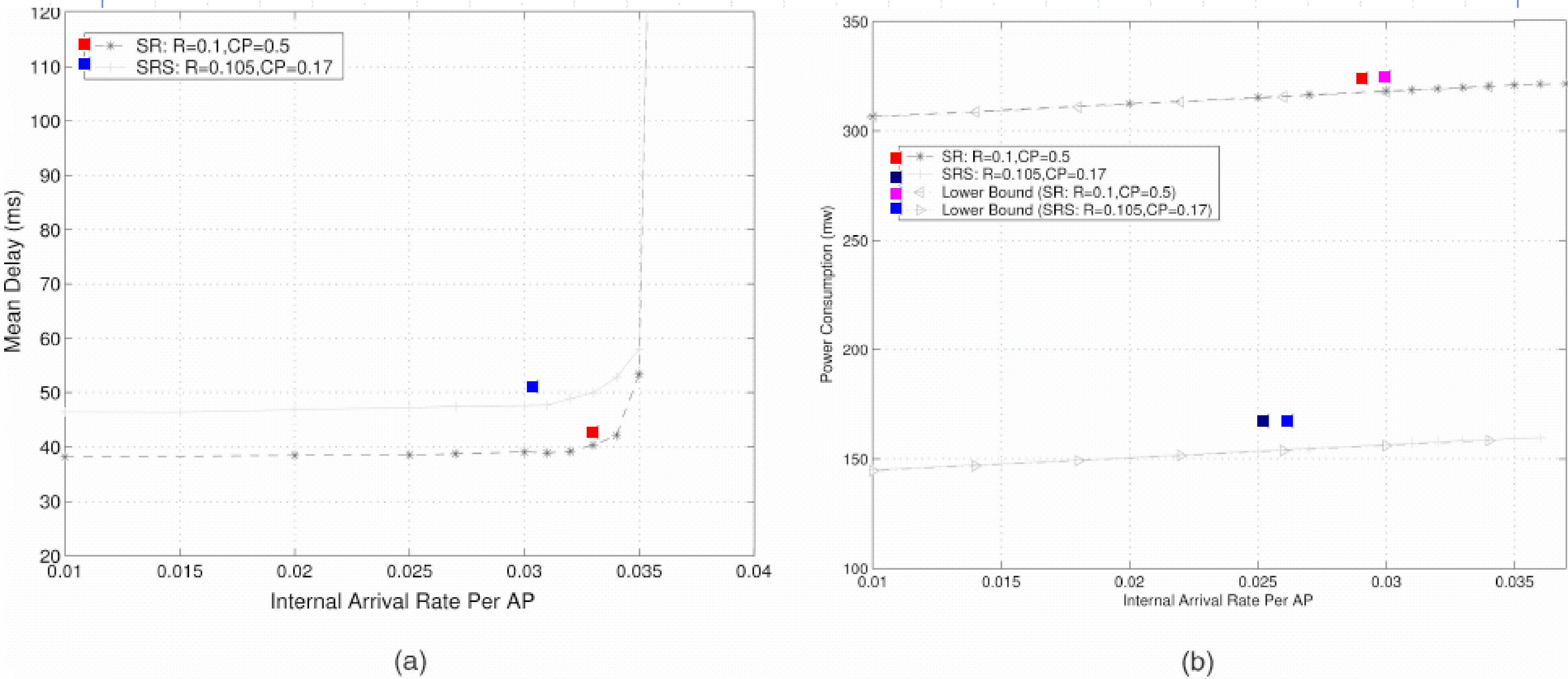


Fig. 13. Comparison of SRS and SR. (a) Mean delay. (b) Mean power consumption.

Performance

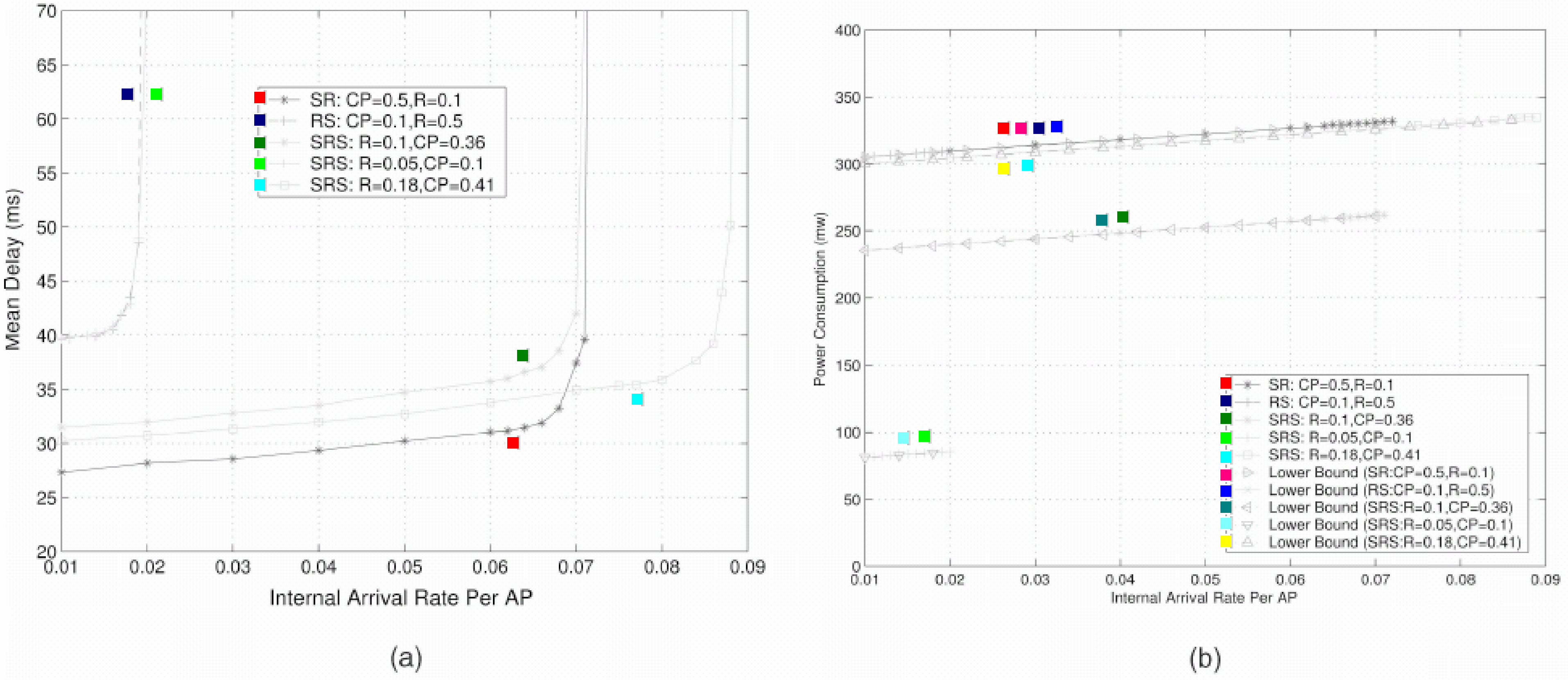


Fig. 14. Partial traffic locality example. (a) Mean delay. (b) Mean power consumption

Performance

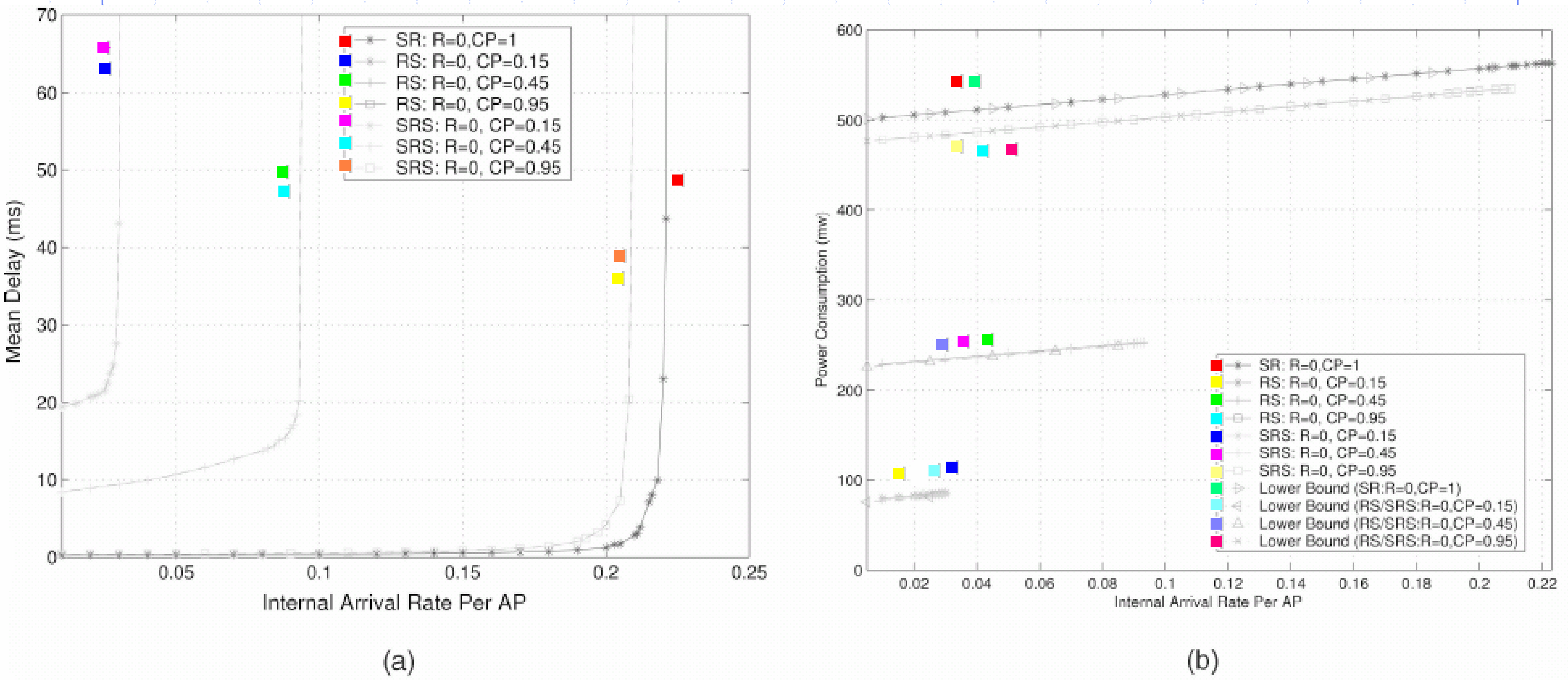


Fig. 15. Traffic locality example. (a) Mean delay. (b) Mean power consumption.

Conclusions

- This paper presented a design for an IEEE 802.11-based power saving access point (PSAP), intended for use in multihop battery and solar/battery powered applications.
- A key design constraint is that the proposed PSAP is backward compatible to a wide class of IEEE 802.11 functionality and existing wired access points.