Wireless Connection Oriented Polling Protocol (WCOPP) Overview

IEEE 802.16 Presentation Submission Template (Rev. 8)

Document Number:

802.16.3p-00/55

Date Submitted:

2000-11-07

Source:

Jon Barton Shields	Voice:	858-642-2726 (Bart Shields),
Jason Krasnow		858-642-2725 (Jason Krasnow)
Larry Butler		858-642-2709 (Larry Butler)
Solectek Corporation	Fax:	858-457-2681
6370 Nancy Ridge Dr Suite #109	E-mail:	bshields@solectek.com
San Diego, CA 92121		jkrasnow@solectek.com
		lbutler@solectek.com

Venue:

IEEE 802 Session; Tampa, Florida; November 2000; 802.16 TG3

Base Document:

Purpose:

It is the intent of the authors that WCOPP act as a "starting point" for the 802.16.3 MAC standard. Where all or a subset of WCOPP are used as the basis for said standard.

Wireless Connection Oriented Polling Protocol (WCOPP) Protocol Overview

Agenda

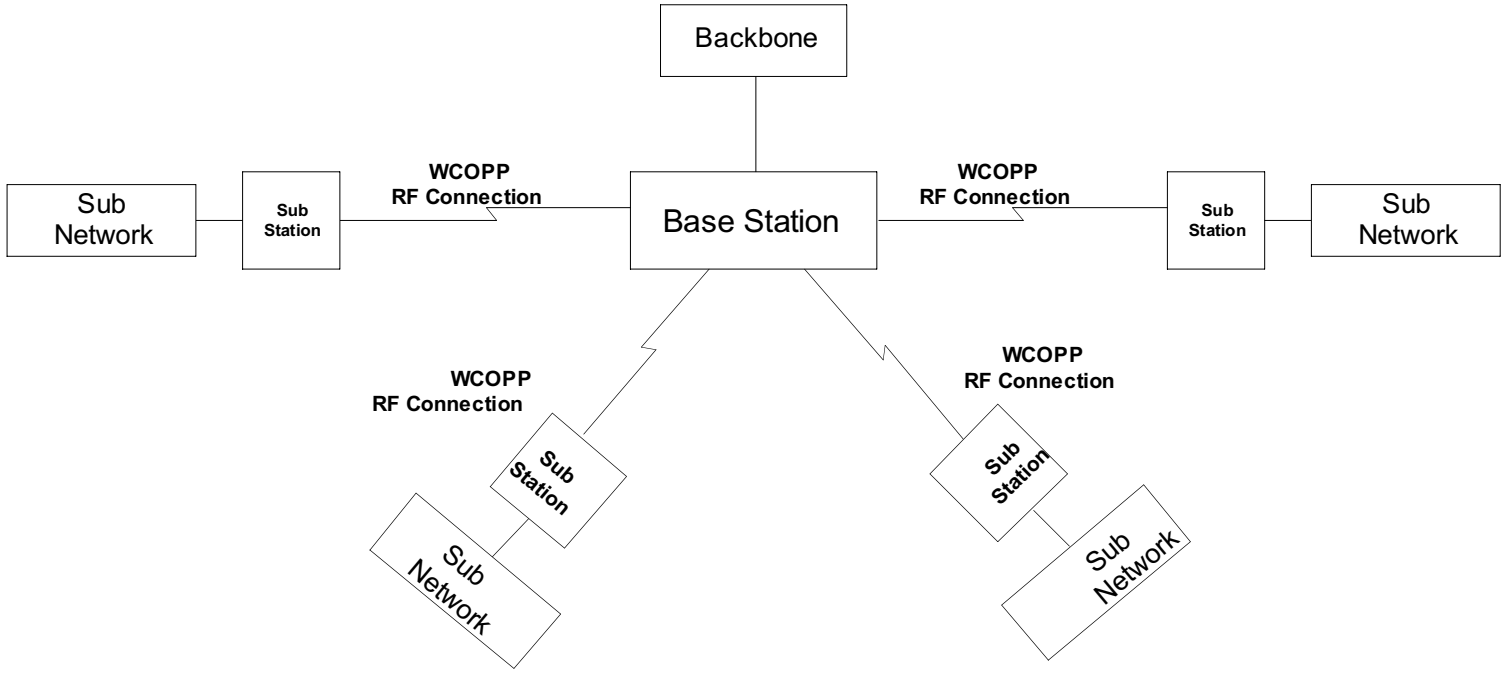
- Introduction
- Network Topology
- System Model
- Performance
- Flexibility
- Services

Introduction

- Based on extended HDLC running in unbalanced mode
  - (i.e. NOT reinventing the wheel, in that a KNOWN protocol was chosen as the base)
- WCOPP is a pure polling protocol
  - No contention period as typically found with collision avoidance which adds complexity and may cause a hidden node problem in certain topologies
- WCOPP is "Connection Oriented"
  - Important, since this allows retransmission at the MAC layer. As wired bit error rates being orders of magnitude worse than that of "wired" technologies (10^{-6} versus 10^{-9} and lower). Thus, reducing latency as well as providing performance similar to that on a wired network.

- WCOPP contains multiple poll lists
  - Sub-stations move dynamically between different polling rates (including PRIORITY polling list(s) for supporting QoS)
- WCOPP encapsulates multiple data types
  - Frame structure similar to frame relay
- WCOPP has association protocol
  - WCOPP-AP allows a CPE unit to discover the correct the base with no configuration on the CPE
  - Minimizes cost of installation
- WCOPP has a basic service set and allows for future expansion
  - Bandwidth management, QoS, encryption are all supported
  - HDLC XID frames are expandable to add future/vendor specific services
- WCOPP allows for ease of implementation since it is based on HDLC and Frame Relay concepts
- WCOPP has no IP configuration embedded within it
  - Leaves the network stack above the MAC to configure the station. (IP can make use of TFTP and DHCP for this)

Network Topology



WCOPP Point-to-Multipoint network configuration

System Model

- WCOPP can be the MAC layer protocol for a broadband subscriber system model

The following steps give a customer example:

- Customer determines a provider in the area with a base-station in line-of-sight
- Customer purchases sub-station (CPE) and aligns antenna according to providers instructions
- Customer gives provider MAC address, serial number, configuration parameters and bandwidth requirements
- Provider configures base-station, creates a configuration file, and sets up any other services (DHCP server, TFTP server, etc..)
- Sub-station then boots and is auto-configured

Sub-Station Auto Configuration

The following steps provide for auto configuration:

- Upon booting the sub-station WCOPP-AP searches for a valid channel
- WCOPP-AP request association with the base-stations on valid channels
- The provider's base-station will recognize the MAC address and accept the station
- WCOPP will start and during authentication the base-station will give bandwidth requirements as well as set up any encryption

5) The IP stack is notified that the link is up

- The sub-station will send out a DHCP request
- The sub-station will receive an IP address and the location of a TFTP server
- The sub-station can then download its configuration file

NOTE: Steps 5-8 are not part of the MAC protocol but are presented as an example method for the system as a whole

Performance

- Frame sequence numbers
  - Efficient retransmission and acknowledgements
- Data encapsulation
  - Allows for minimal translation for bridging
- Multiple polling rates
  - Sub-Station moves between fast, slow and inactive polls to provide maximum throughput and minimal latency for “bursty” network traffic
- Allows Large Frame Sizes (Dynamically Changeable)
  - Configurable up to 8192 bytes
  - Allows for efficient packing of local LAN frames into sub-frames
  - Allows for MAC layer fragmentation/defragmentation
- Proven real-world performance
  - Benchmarked using RFC2544 compliant devices
  - 10Mb/s aggregate bridging and routing throughput over 11Mb/s DSSS link

Flexibility

- Flexible Encapsulation
  - OUI for bridged frames
  - PID for routed frames
  - Expandable for future for use
- Standard Addressing
  - 48 MAC addresses
    - Allows for universal MAC administration
    - Multicast Traffic

Frame Structure

Basic Frame Structure:

Address	Control	Information (optional)	FCS
48 Bits	8 or 16 Bits	0 - 8096 bytes.	32 bits

Information Sub-Frame:

Length	Flags	Sub-Station Address (optional)	Destination Address (optional)	Fragmentation	OUI	PID	PDU
16 bits	16 bits	48 bits	48 bits	8 bits	24 bits	16 bits	M * 8 bits

Management Information Sub-Frame:

Identifier	Length	Data (optional)
8 bits	8 bits	0 – 255 bytes.

Services Provided

- Bandwidth Management
- Sub-Station Association
- Sub-Station Authentication
- Quality of Service
- Dynamic Power Control
- Signal/Noise

Bandwidth Management

- Central Bandwidth Management
  - Bandwidth allocated by base-station
  - Sub-station bandwidth configured at base-station
- Limited Bandwidth
  - Channel is limited to a specific bandwidth. Generally used when selling of a dedicated line to the CPE.
  - Allows for over subscription of bandwidth.
- Guaranteed Bandwidth
  - May be a constant bandwidth guarantee
  - Bandwidth can be dynamically granted on a per-poll basis

Sub-Station Authentication

- WCOPP-AP pre-authentication for creating private enterprise networks
- WCOPP authentication for shared key encryption algorithms
- Expandable for future encryption algorithms

Quality of Service

- Priority polling.
- Priority queues on both the transmit and receive side of the link. It is an implementation dependent detail as to the actual number of queues per link and is not mandated by the protocol. Obviously though, there needs to be at least a “High-Priority” queue and a “Normal Priority” queue per link.
- Message tagging (allows receive side of link to properly route priority frames).

Sub-Station Association

- WCOPP-AP provides the mechanism for sub-stations to discover and link to a base-station, via “Channel Searching”
- Base-Stations can be configured to accept only certain sub-stations to avoid ‘enemy’ sub-stations
- Pre-Authentication can be used to avoid ‘enemy’ base-stations
- Association also provides a means for accepting any station using promiscuous mode
- Association can also be made through operator intervention using WCOPP-AP standby mode

- Sub-station has a configurable retry time on channels which it was denied because the base-station was at capacity
- Central management of sub-station connections from the base-station
  - Connection can be terminated from the base-station or sub-station through disassociation

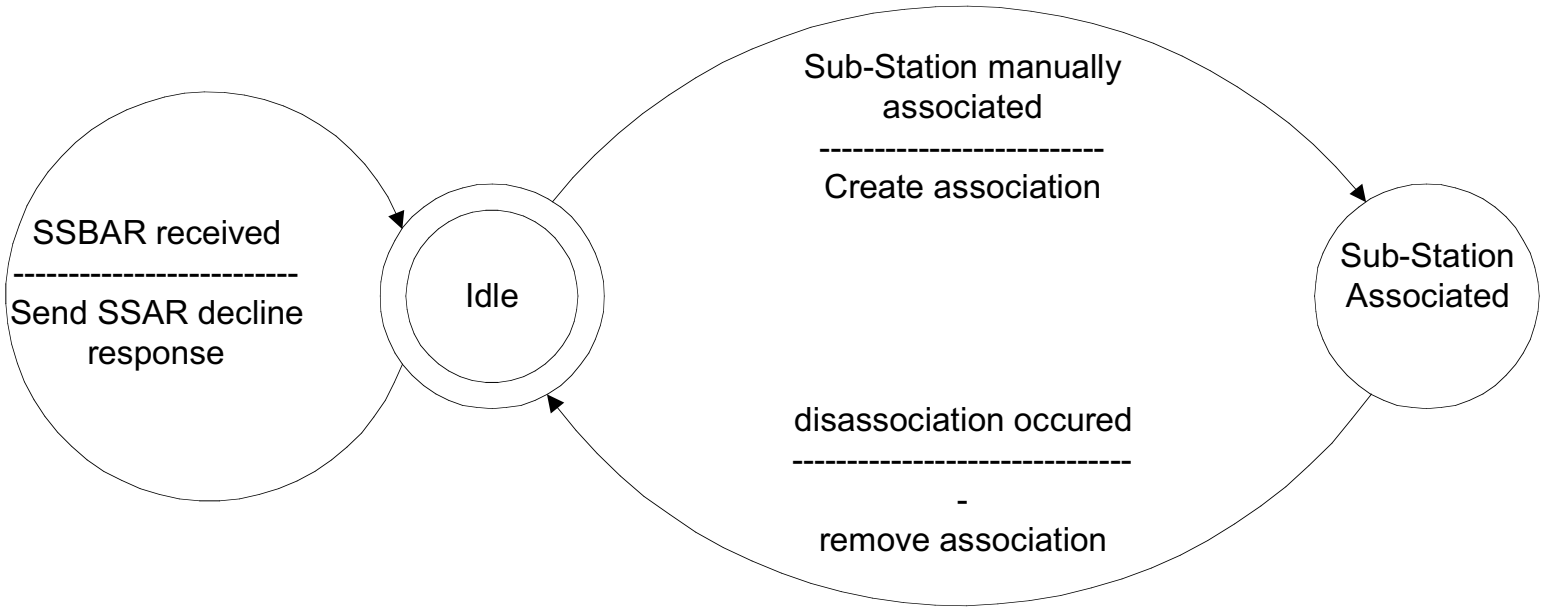
Dynamic Tx Power Control

- Transmit power controlled by each station
- Base-station periodically transmits a power control start frame
  - The period of this is configurable
- All stations respond simultaneously
- All stations measure their transmit power and adjust it accordingly

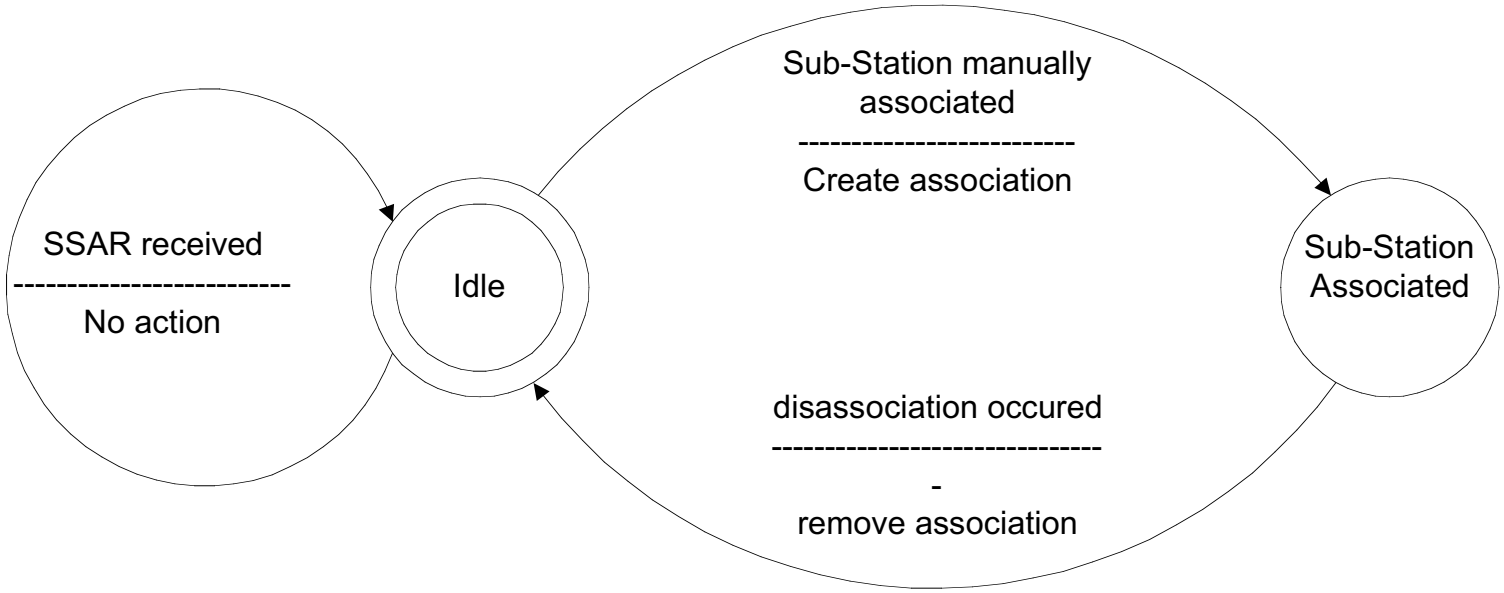
Signal/Noise

- Signal and Noise level are transmitted through XID frames
- Allows base-station to adjust link according to the S/N data received

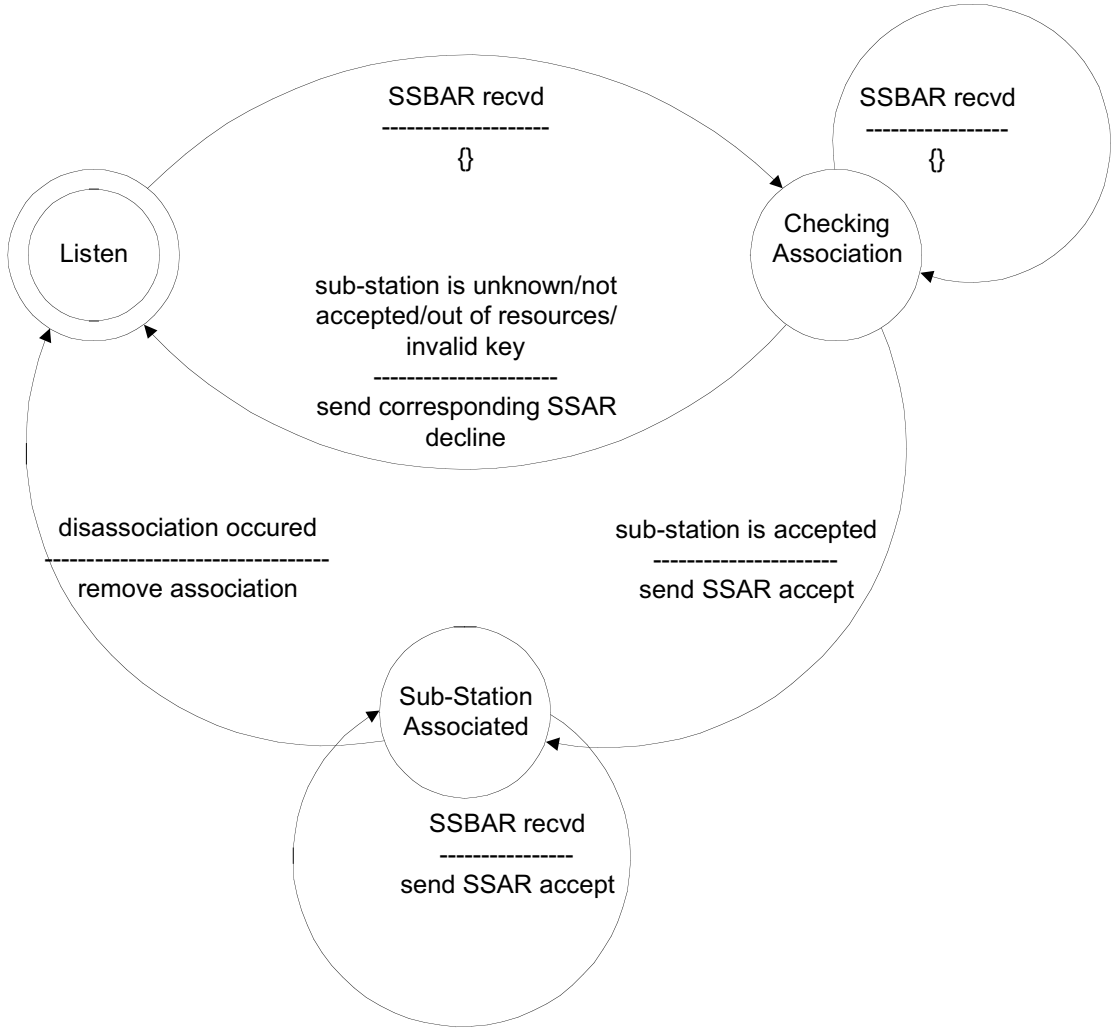
Base-Station Manual Configuration FSM



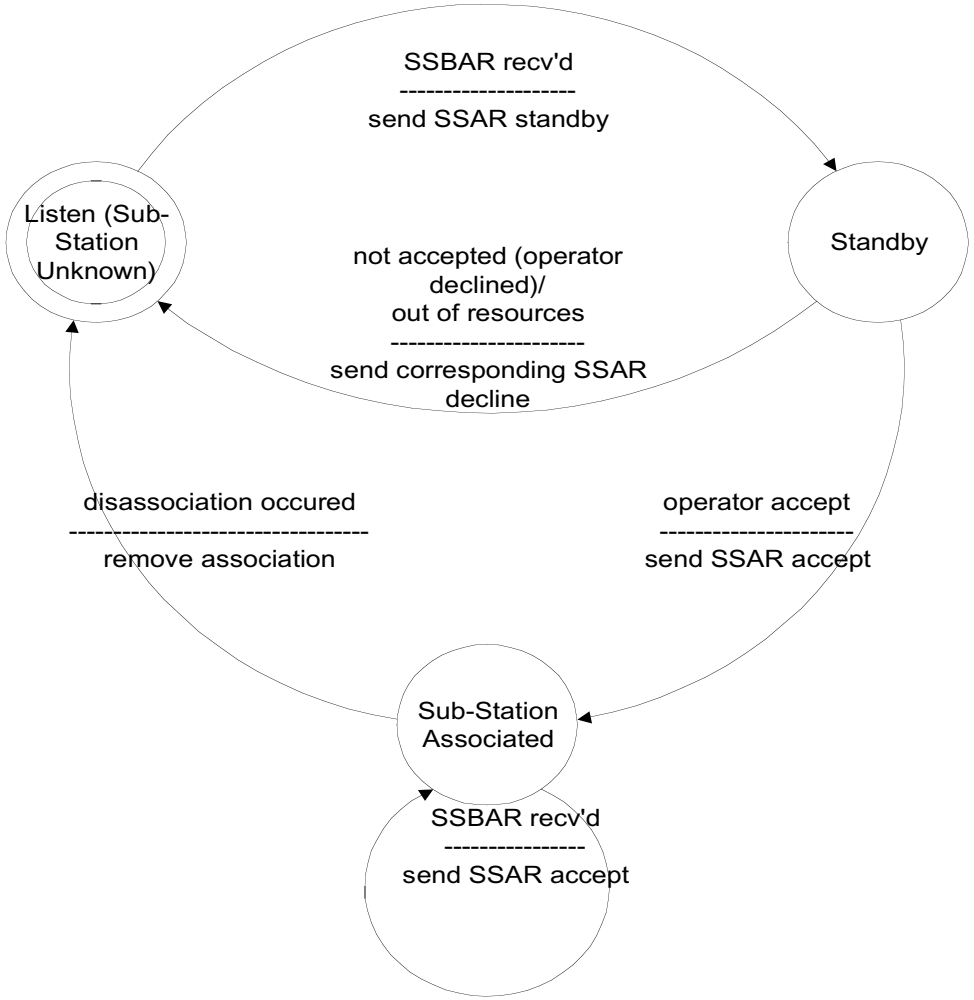
Sub-Station Manual Configuration FSM



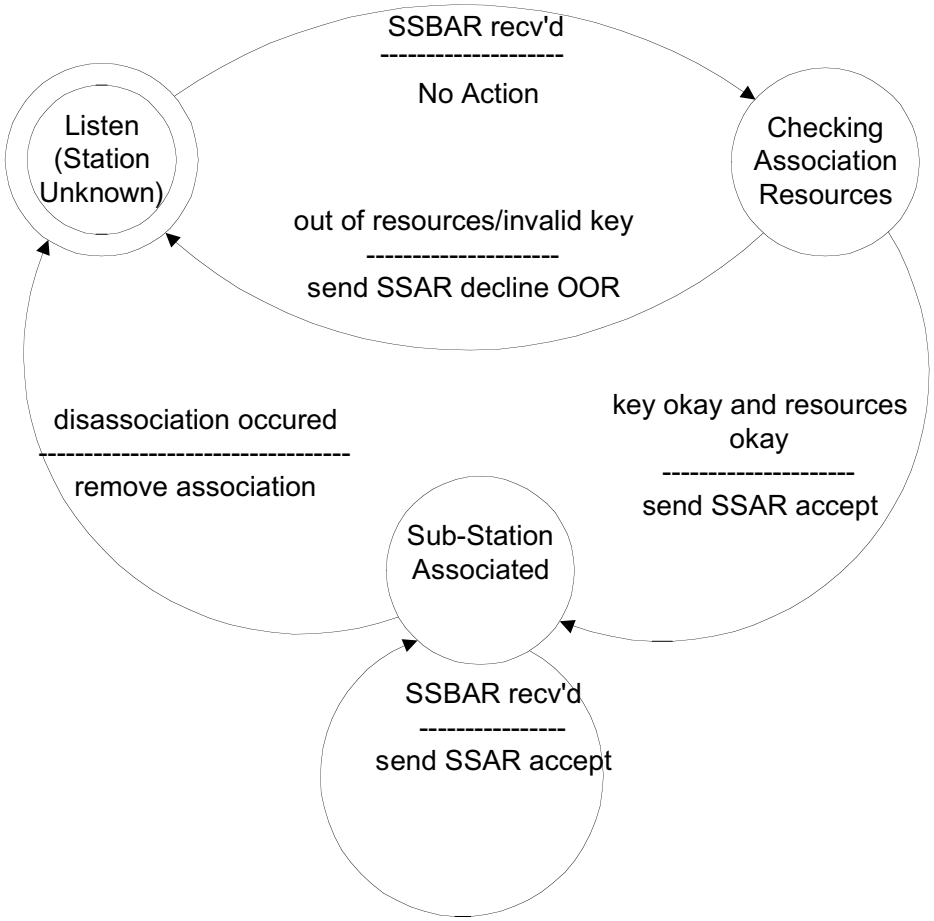
Base-Station WCOPP –AP Standard Mode FSM



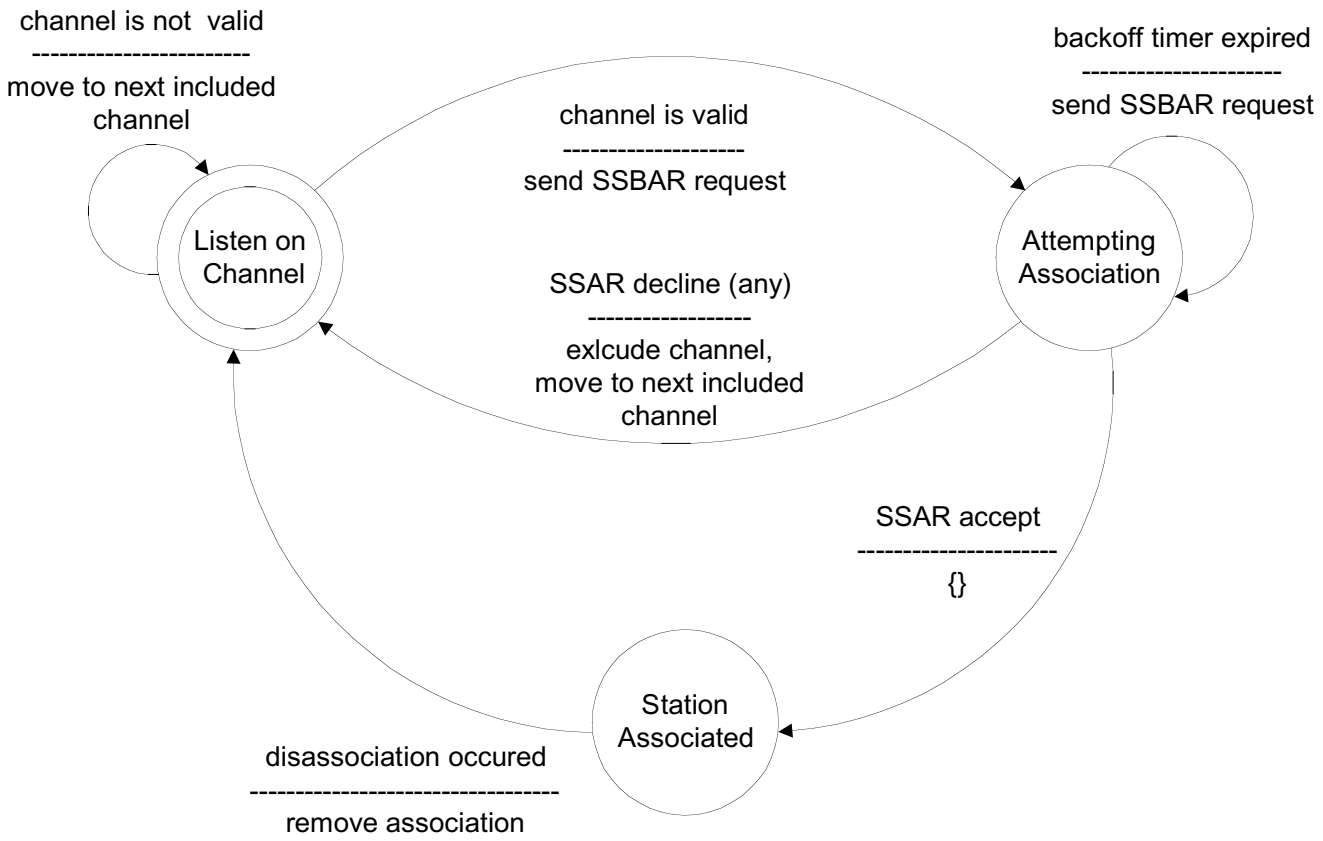
Base-Station WCOPP – AP Standby Mode FSM



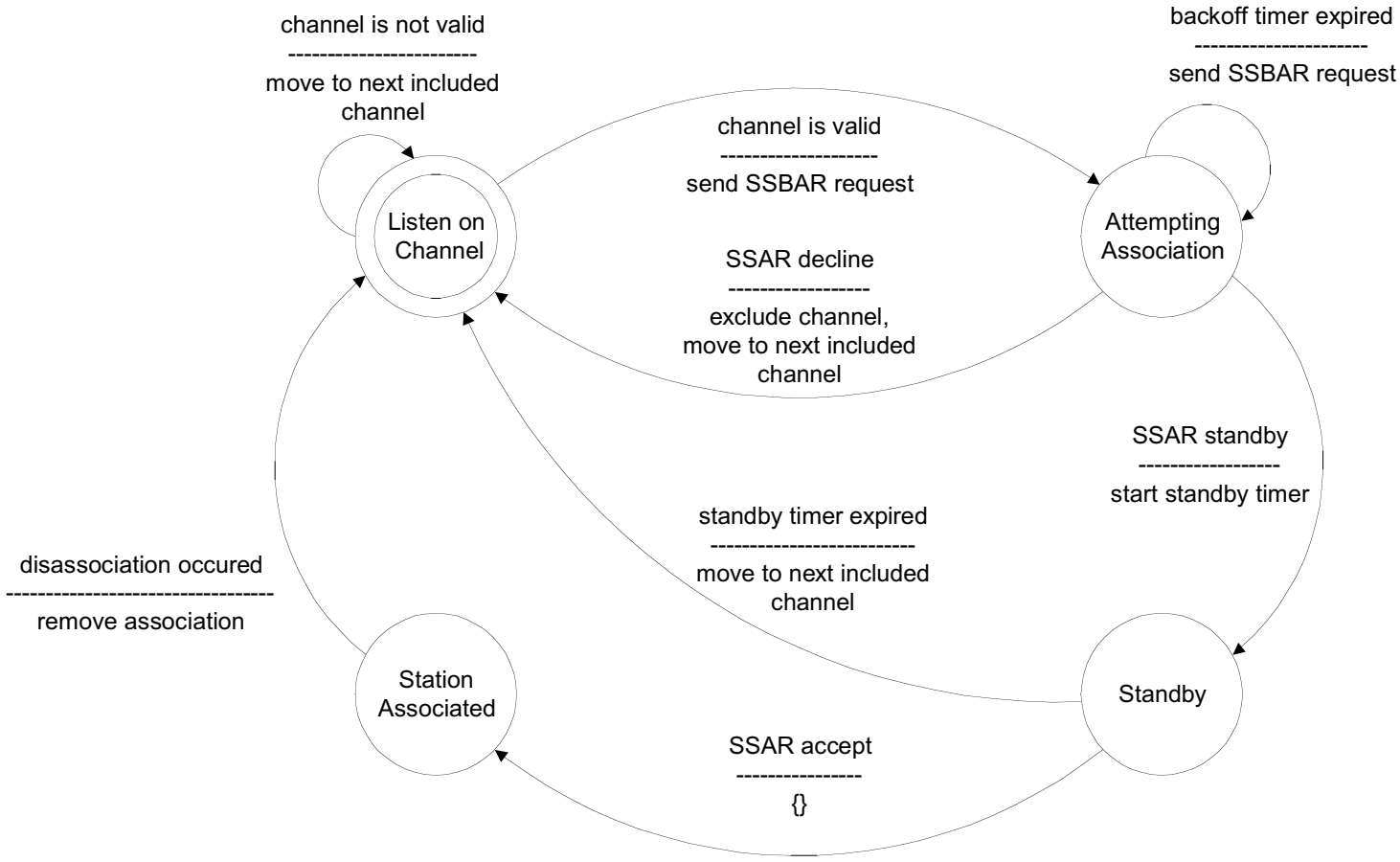
Base-Station WCOPP – AP Promiscuous Mode FSM



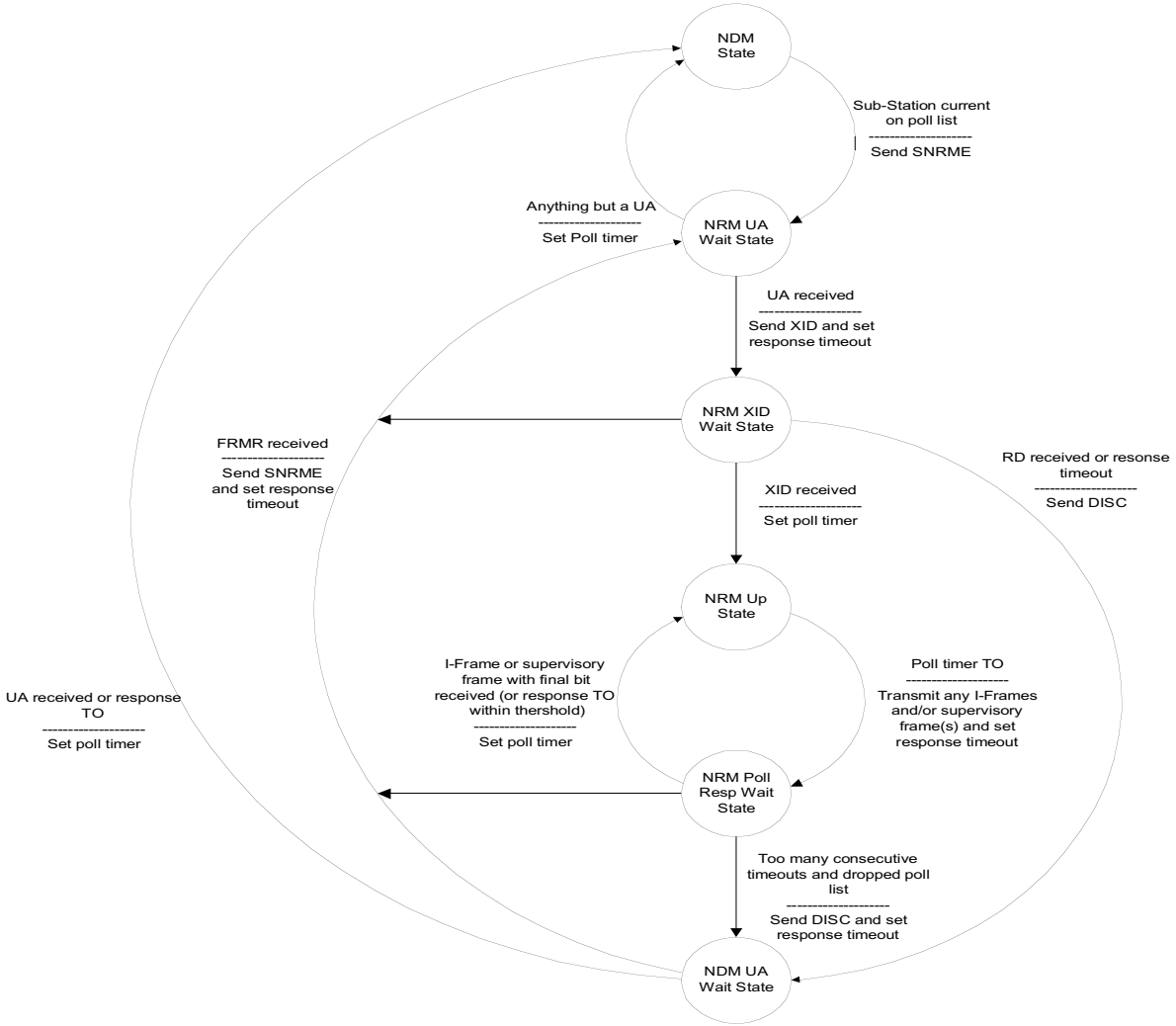
Sub-Station WCOPP – AP Standard Mode FSM



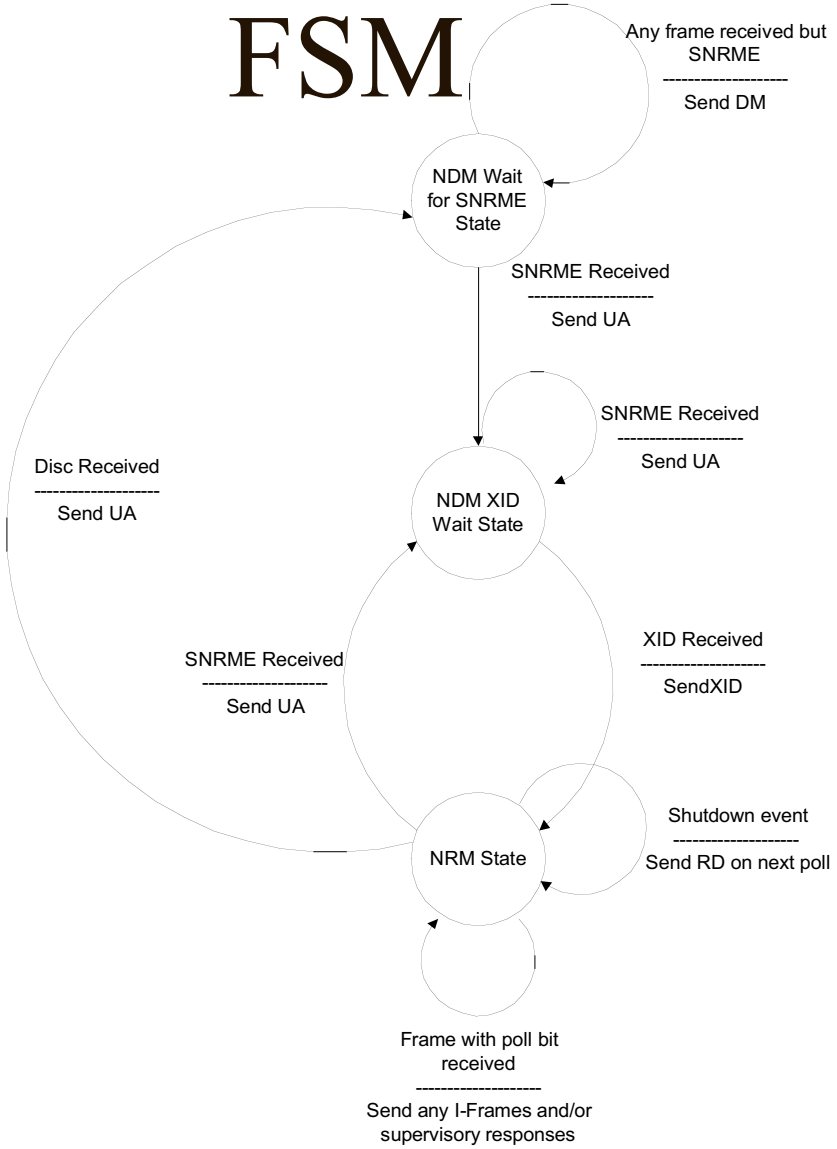
Sub-Station WCOPP – AP Standby Mode FSM



WCOPP Base-Station Connection FSM

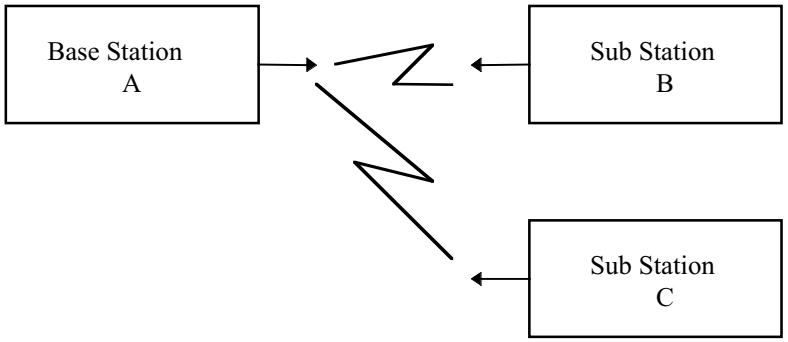


WCOPP Sub-Station Connection FSM



WCOPP Protocol Dialogs

Protocol Dialog Example Configuration



In the following examples the following frame diagramming conventions are used:

The station letter address is given (B or C) followed by a comma,
The command or response operation acronym is given,
The Ns count is given within parenthesis if required and a hyphen if not,
The poll or final bit is indicated by a P or F = 1 or 0,
The Nr count is given within parenthesis if required.
The left column shows frames originating from the base-station while the right column shows frames originating from the either sub-stations

Sub-Station WCOPP-AP Startup

	▪ B, SSBAR	B requests association with base
B, SSAR Decline ®		A declines B's request
	▪ B, SSBAR	B switches channels and requests association with base2
B, SSAR Accept ®		A2 accepts B's request

Sub-Station Begins WCOPP Dialogue

B, RR - P=1 (0) ®

B, RR - P=1 (0) ®

B, SNRME-P=1 ®

B, XID - P=1 ®

B, RR-P=1 (0) ®

- B, DM - F=1
- B, UA-F=1
- B, XID - F=1
- B, RR-F=1 (0)

A polls B.

TIMEOUT - B not responding.
A polls B.
B reports disconnected status.
A sets B's response mode.
Nr and Ns counts reset to zero
B acknowledges.
A informs B of configuration
B informs A of configuration
A polls B for transmission.

B has nothing to transmit.

WCOPP Normal Polling Operation

B, RR-P=1 (0) ⑧

- B, I (0) F=1 (0)

A polls B for transmission. B sends final I-Frame.

B, RR-P=1 (1) ⑧

A confirms frame 0 and polls B for transmission.

- B, I (1) F=0 (0)
- B, I (2) F=0 (0)
- B, I (3) F=1 (0)

B sends numbered I-Frames

B, I (0) P=0 (4) ⑧

A confirms frames 1-3 and starts sending numbered I-Frames.

B, I (1) P=0 (4) ⑧

B, I (2) P=1 (4) ⑧

A sends poll I-Frame.

- B, RR-F=1 (3)

B confirms frames 0-2.

Sub-Station Detects Sequence Error

B, RR - P=1 (0) ⑧		A polls B for transmission.
	▪ B, I (0) F=0 (0)	B sends numbered I-Frames.
	▪ B, I (1) F=1 (0)	
B, I (0) P=0 (2) ⑧		A sends numbered I-Frames and acknowledges frames 0 and 1.
B, I (1) P=0 (2) ⑧		CRC error, frame discarded by B.
B, I (2) P=1 (2) ⑧		A sends poll frame.
	▪ B, REJ - F=1 (1)	B expects Frame 1.
B, I (1) P=0 (2) ⑧		A retransmits frames 1 and 2.
B, I (2) P=1 (2) ⑧		
	▪ B, RR - F=1 (3)	B confirms frames 1 and 2.

Two Sub-Stations with One Congested

B, I (4) P=0 (3) ⑧		A sends numbered I-Frames to B.
B, I (5) P=1 (3) ⑧		Last frame is poll frame.
	▪ B, RNR - F=1 (5)	B is congested but acknowleges frame 4.
C, RR - P =1 (29) ⑧		A polls C.
	▪ C, RR - F-1 (8)	C has nothing to send.
B, RR - P=1 (3) ⑧		A checks if B still congested.
	▪ B, RR - F=1 (5)	B can receive now and expects frame 5.
B, I (5) P=0 (3) ⑧		A sends frame 5 again.
B, I (6) P=1 (3) ⑧		A continues with frame 6 and polls B.
	▪ B, RR - F=1 (7)	B confirns frames 5 and 6.