Simplex Physical Layer State Machine

Eric L. Scace K3NA
10701 Five Forks Road
Frederick MD 21701
USA

0. Summary

This paper is part of a series of papers which provide extended finite state machine representations for AX.25 and related protocols. The state machines are depicted using state description language (SDL) graphic conventions from the 2.100 series of Recommendations developed by the International Telegraph and Telephone Consultative Committee (CCITT) of the International Telecommunications Union (ITU). An extended finite state machine representation of a communications protocol such as AX.25 avoids the ambiguities associated with prose descriptions. These descriptions also compel1 the protocol designer to confront many of the error scenarios which arise on a communications path, and simplify the implementor's task of producing correct solutions which will interwork with solutions created by others.

This particular paper describes an extended finite state machine suitable for use on shared simplex radio channels; such channels represent the vast majority of environments where AX.25 is employed today. A sister paper describes a similar machine suitable for use on full duplex channels.

1. Status of Proposal

The half-duplex physical SDL description here is a draft. The ARRL Digital Committee intends to include this machine as an Annex of the upcoming publication of AX.25 Revision 2.1.

Written comments have been received by the Committee which note the lack of material in the present description of AX.25 (i.e., Revision 2.0) which describe important parameters and operating procedures associated with half-duplex radio channels. In the dim dark days of the past, the original intent of the Committee was to focus the Rev. 2.0 publication strictly on the link layer protocol aspects of AX.25. It now seems prudent to include additional helpful information, not related to the link layer protocol in the strict architectural sense, which would be helpful in the correct understanding and implementation of AX.25 over radio channels.

The following material is still in a draft state. You are invited to review and comment on this material. Comments are desired so that the final publication is as useful as possible to its readers.

2. Features of the Simplex Physical SDL Machine

The simplex physical SDL machine includes the following features:

a) preferential treatment for frames to be digipeated, including a DWAIT timer.
b) guard times for changeover between receive and transmit.
c) guard times for a traditional repeater (i.e., AXDELAY and AXHANG).
d) p-persistence algorithm to improve channel utilization under heavy load (suggested by Chepponis & Karn at the 6th Computer Networking Conference).
e) 10 minute transmitter protection limit.
f) an independent anti-hogging function which relinquishes control of the channel after a user-specified period of time.
g) independent queuing of frames being digipeated and "normal" frames to be transmitted.

3. Location in Overall Model

This SDL machine resides at the physical (lowest) layer of the standard Open Systems Interconnection reference model. It interacts with the link multiplexor SDL machine above it, and directly with a typical radio transceiver below it.

3.1 Interaction with the Link Multiplexor

The Link Multiplexor SDL machine directs the operation of the simplex physical SDL machine through the primitives described below. "PH" in some primitive names stands for "physical".

PH Seize Request -- This primitive requests the simplex physical SDL machine to begin transmitting at the next available opportunity. When that opportunity has been identified (according to the CSMA-CD/p-persistence algorithm included within), the transmitter started, a parameterized window provided for the start-up of a conventional repeater (if

required), and a parametrized time allowed for the synchronization of the remote station's receiver (known as TXDELAY is most implementations), then a **PH Seize Confirm** primitive is returned to the Link Multiplexor.

Normal Frame -- This primitive from the Link Multiplexor SDL machine provides an AX.25 frame of any type (UI, SABM, I, etc.) which is to be transmitted. An unlimited number of frames may be provided. If the transmission exceeds the lo-minute limit or the anti-hogging time limit, the half-duplex physical SDL machine automatically relinquishes the channel for use by other stations. The transmission is automatically resumed at the next transmission opportunity indicated by the CSMA-CD/p-persistence contention algorithm.

PH Release Request -- The Link Multiplexor SDL machine provides this primitive when the submission of a sequence of frames to be transmitted on behalf of a particular AX.25 connection has been completed. The simplex physical SDL machine will then piggyback any straggling digipeat frames (if time permits) and then relinquish the channel.

Digipeat Frame -- This primitive from the Link Multiplexor SDL machine provides an AX.25 frame which is being digipeateci. The simplex physical SDL machine gives preference to digipeated frames over normal frames, and will take advantage of the DWAIT window. Digipeat frames can be provided by the Link Multiplexor at any time; a PH Seize Request and subsequent PH Release Request are not employed for digipeating.

During reception, the simplex physical SDL machine provides each AX.25 frame to the Link Multiplexor in a **Frame** primitive. No analysis is done on the frame by the simplex physical SDL machine; it does not. examine lengths, the frame check sequence, the need for digipeating, or any other content of the frame; these responsibilities are carried out by the higher level SDL machines.

In addition, the simplex physical SDL machine provides **PH Busy Indication** whenever the channel becomes busy. "Busy" here means the detection of a valid modem synchronization sequence, HDLC flags, or HDLC frames; it does *not* mean FM carrier detection on a 2-meter radio! The assumption here is that the channel (if FM) is not shared by voice users (although such sharing would be possible by expanding the meaning of "busy" in this sense) An indication of busy is provided to the higher layer SDL machines so that various timers which supervise the AX.25 connection can be suspended. This avoids the undesirable situation on a busy channel where AX.25, having sent data and expecting an acknowledgement, times out and attempts retransmissions -- and the only reason an acknowledgement was not received was because the remote station did not yet have a chance to make a transmission. **PH Quiet Indication** is provided when the channel becomes quiet again.

Since the channel is simplex, the PH Busy Indication and PH Quiet Indications are also provided when the simplex physical SDL machine causes a transmission to occur.

3.2 Interface to the Radio

As the lowest layer (in an Open Sys terns Interconnection achitectural sense) machine within a TNC, this machine is envisioned to manipulate a typical radio transceiver.

Turn On Transmitter and **Turn Off Transmitter** primitives are used to manipulate the transceiver's PIT line.

The simplex physical SDL machine sends a **Frame** primitive represents the actual transmission of a frame. Although SDL representation of bit-by-bit transmission of the contents of the frame are possible, they are not used here because the additional complexity was not required. The Frame primitive, however, differs from all other primitives used in these SDL machines in one respect: it is not atomic. Under this model, the Frame primitive occupies time; this allows the simplex physical SDL machine to consume time associated with transmission, and to trigger the 10 minute transmitter protection and anti-hogging timers.

Similarly, the simplex phsyical SDL machine employs a simple model of reception which collapses bit-by-bit reception of AX.25 frames into a single incoming primitive called **Frame.** The detection of modem synchronization, flag fill, or frame structure trigger the **Acquisition of Signal** primitive. The loss of modem synchronization, flag fill, or framing triggers the **Loss of Signal** primitive.

4. Internal Operation of the Machine

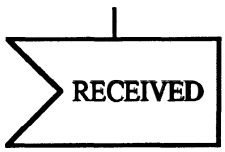
The internal states, queues, flags, and timers are summarized on the first page of the SDL diagram. All queues are first-in first-out queues. These items are used in a straightforward manner, so no further explanation will be provided here.

It should be noted that the anti-hogging time limit is not applied to the digipeating function. However, the lo-minute transmitter timer is enforced while digipeating. In the unlikely event that the lo-minute limit is exceeded, the transmission of digipeated frames is temporarily suspended and the channel relinquished. After other stations have had the opportunity to digipeat frames (i.e., DWAIT expires), but before the p-persistence algorithm kicks in, the SDL machine jumps back on the channel to resume transmission of those frames still in the digipeat queue. While this logic: is provided in the SDL diagrams for completeness, it seems unlikely that it would ever be utilized.

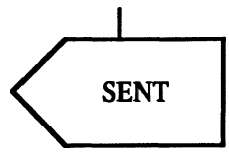
SIMPLEX PHYSICAL

Summary of Primitives, States, Queues, Flags, Errors, and Timers

PH Primitives

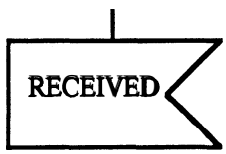


PH Sieze Request
PH Release Request
Digipeat Frame
Normal Frame



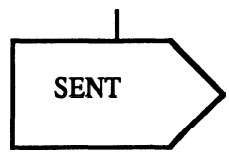
PH Seize Confirm
PH Busy Indication
PH Quiet Indication
Frame

PH Primitives



Acquisition of Signal
Loss of Signal
frame

Note -- Acquisition and loss of signal do NOT refer to FM carrier detect, but rather to modem synchronization, HDLC flags, and HDLC framing.



Turn On Transmitter
Turn Off Transmitter
Frame

Note -- Frame primitive is not atomic; it consumes the time needed to actually transmit the frame.

States

0 -- Ready
1 -- Receiving
2 -- Transmitter Suppression
3 -- Transmitter Start
4 -- Transmitting
5 -- Digipeating
6 -- Receiver Start

Error Codes

No error codes used.

Queues

Digipeat Queue -- holds all frames to be digipeated in the order in which they arrived from the higher layer.

Normal Queue -- holds all normal frames, plus Seize and Release Requests, in the order in which they arrived from the higher layer.

Flags & Parameters

Digipeating -- Set when this transmission is for digipeating frames. Cleared when this transmission is for normal frames.

Repeater Up -- Set when repeater is expected to still be transmitting. Cleared when repeater carrier is expected to have dropped.

Interrupted -- Set when anti-hogging or 10 minute transmitter limits have interrupted the transmission of normal frames.

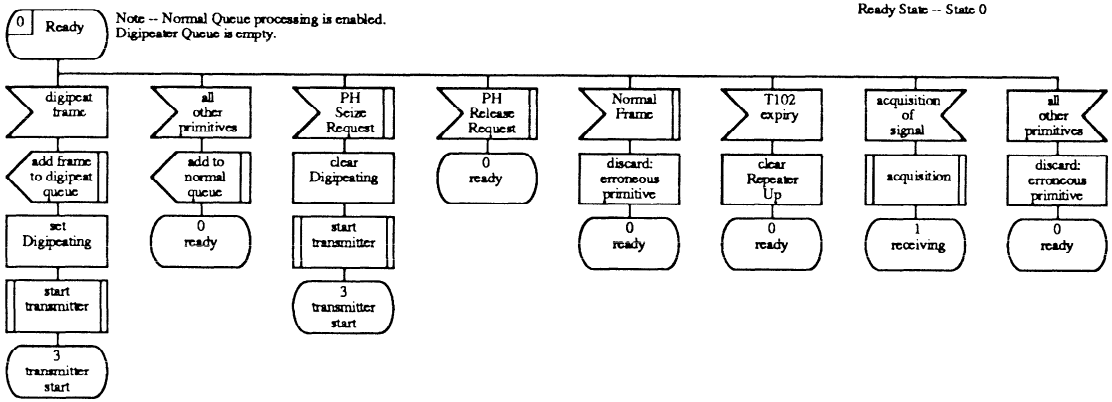
p -- p-persistence value, in the range O-l.

Timers

T100 -- repeater hang (AXHANG).
T101 -- digipeater window (DWAIT)
T102 -- slot time (p-persistence)
T103 -- transmitter startup
T104 -- repeater startup (AXDELAY)
T105 -- remote receiver sync (TXDELAY)
T106 -- 10 minute transmission limit
T107 -- anti-hogging limit
T108 -- receiver startup

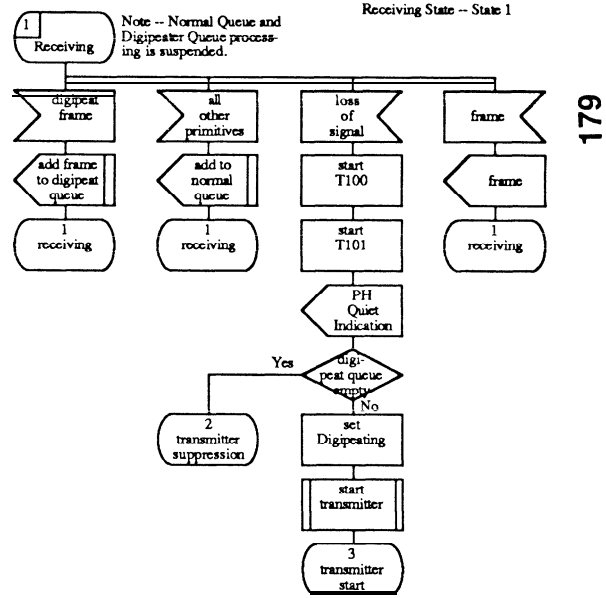
Simplex Physical

Ready State -- State 0



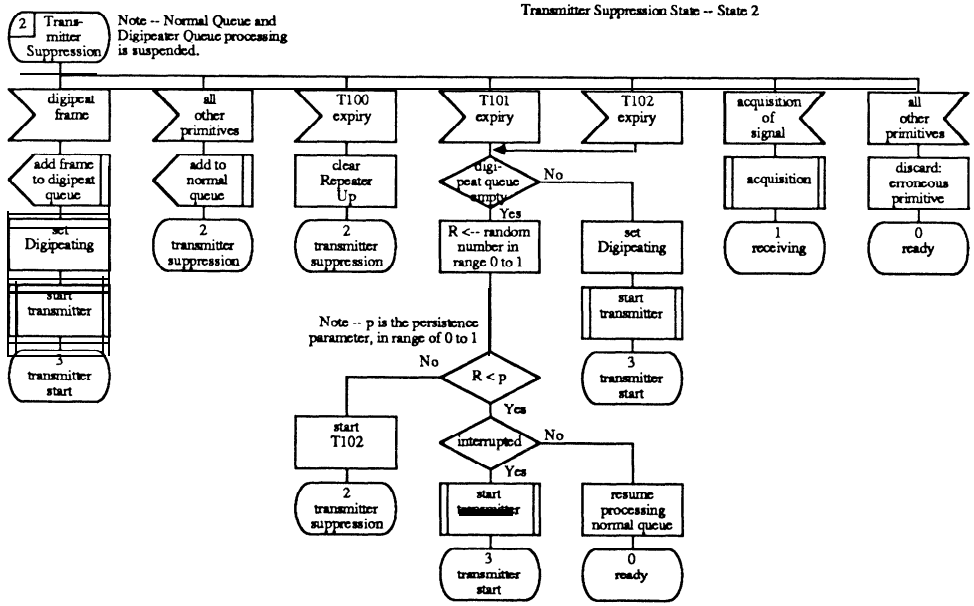
Simplex Physical

Receiving State -- State 1



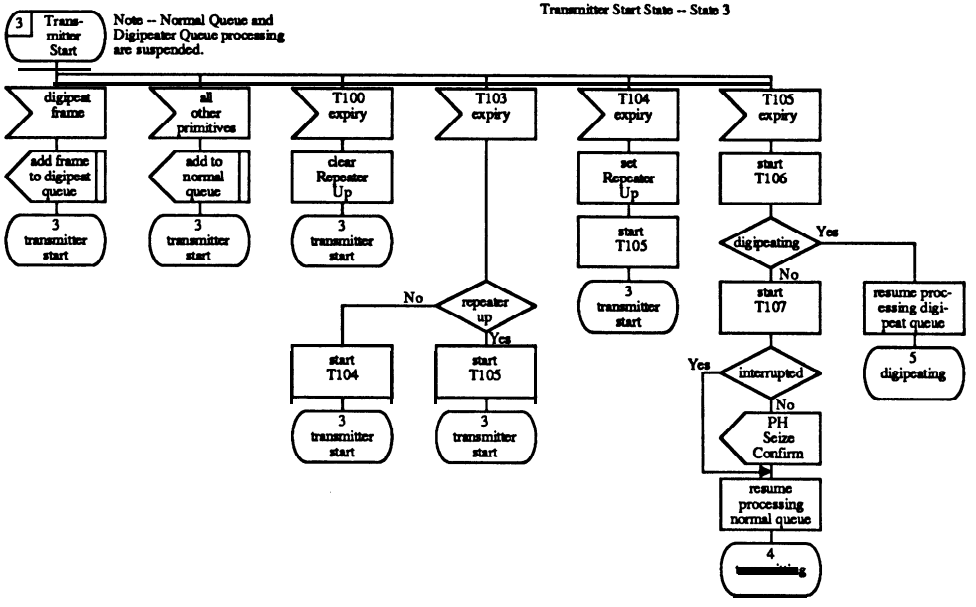
Simplex Physical

Transmitter Suppression State -- State 2



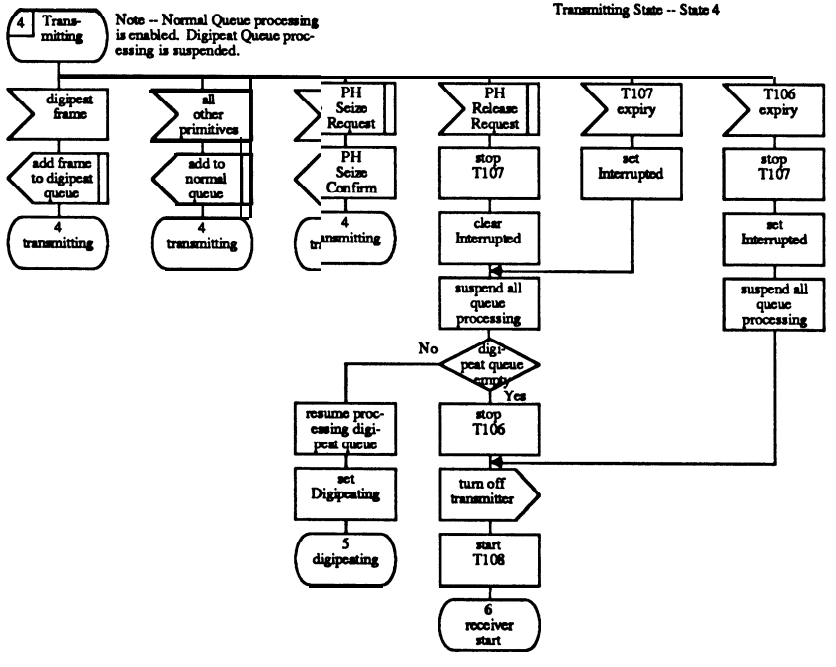
Simplex Physical

Transmitter Start State -- State 3

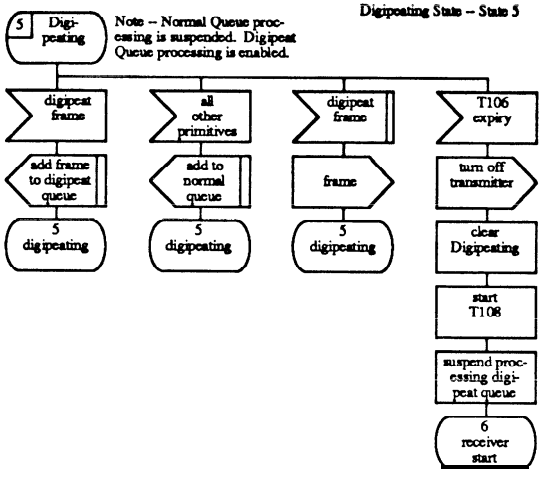


Simplex Physical

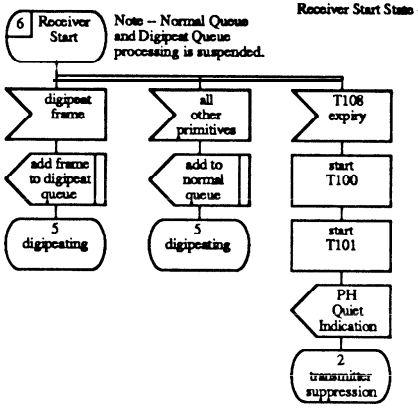
Transmitting State -- State 4



Simplex Physical
Digipeating State – State 5



Simplex Physical
Receiver Start State – State 6



Simplex Physical
Subroutines