3GPP2 C.S0025

Ballot Resolution Version

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Markov Service Option (MSO) for cdma2000 Spread Spectrum Systems

(Ballot Resolution Version)

No text.

Contents

Figures

Tables

FOREWORD

This document specifies procedures for the Markov Service Option (MSO). The MSO is used to allow verification of the physical layer performance frame error rate (FER) of the cdma2000 Fundamental channels.

These technical requirements form a specification for the two-way Markov service option. This specification does not address the reliability of Markov service option, nor does it cover equipment performance or measurement procedures.

The document is organized into the following sections:

- Chapter 1 defines the terms and notations used in this document.
- Chapter 2 provides a general description of the MSO and describes the detail procedures and operation of the mobile station and the base station for the MSO.
- Chapter 3 provides the message format.
- Annex A is an informative section that outlines a procedure for conducting a Markov test. It also shows the use of the transmit and receive counters for estimating the Frame Error Rate (FER) for the Forward and Reverse Fundamental Channels.
- Annex B is an informative section that provides examples of setting up a Markov call in the CDMA system using service negotiation.
- Annex C is an informative section that shows examples of data block generation.
- Annex D is an informative section that lists the documents that may be useful in implementing the MSO.

NOTES

1. "Base station" refers to the functions performed on the landline side, which are typically distributed among a cell, a sector of a cell, and a mobile communications switching center.

2. The following verbal forms: "Shall" and "shall not" identify requirements to be followed strictly to conform to the specification and from which no deviation is permitted. "Should" and "should not" indicate that one of several possibilities is recommended as particularly suitable, without mentioning or excluding others, that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is discouraged but not prohibited. "May" and "need not" indicate a course of action permissible within the limits of the specification. "Can" and "cannot" are used for statements of possibility and capability, whether material, physical, or causal.

3. Footnotes appear at various points in this specification to elaborate and further clarify items discussed in the body of the specification.

4. Unless indicated otherwise, this document presents numbers in decimal form.

5. Binary numbers are distinguished in the text by the use of single quotation marks. In some tables, binary values may appear without single quotation marks if the table notation clearly specifies that values are binary. The character 'x' is used to represent a binary bit of unspecified value. For example 'xxx00010' represents any 8-bit binary value such that the least significant five bits equal '00010'.

6. Hexadecimal numbers (base 16) are distinguished in the text by use of the form 0xh…h where h…h represents a string of hexadecimal digits. For example, 0x2fa1 represents a number whose binary value is '10111110100001' and whose decimal value is 12193. Note that the exact number of bits in the binary representation of a hexadecimal number strictly depends on the implementation requirements for the variable being represented.

7. The following conventions apply to mathematical expressions in this specification:

   - $\lfloor x \rfloor$ indicates the largest integer less than or equal to x: $\lfloor 1.1 \rfloor = 1$, $\lfloor 1.0 \rfloor = 1$.
   - $\lceil x \rceil$ indicates the smallest integer greater than or equal to x: $\lceil 1.1 \rceil = 2$, $\lceil 2.0 \rceil = 2$.
   - $|x|$ indicates the absolute value of x: $|-17|=17$, $|17|=17$.
   - min(x, y) indicates the minimum of x and y.
   - max(x, y) indicates the maximum of x and y.

- In figures, × indicates multiplication. In formulas within the text, multiplication is implicit. For example, if h(n) and $p_L(n)$ are functions, then h(n) $p_L(n)$ = h(n) × $p_L(n)$.
- x mod y indicates the remainder after dividing x by y: x mod y = x - (y $\lfloor x/y \rfloor$).
- x ∈{ a, b, c } indicates x is a member of the set comprised of elements a, b, and c.
- The bracket operator, [ ], isolates individual bits of a binary value. VAR[n] refers to bit n of the binary representation of the value of the variable VAR, such that VAR[0] is the least significant bit of VAR. The value of VAR[n] is either 0 or 1.
- x ≈ y indicates that x is approximately equal to y.

8. The following conventions apply to expressions in the pseudo code in this specification:

- x & y represents the bit-wise AND operation between the binary representation of x and y: 31 & 4 = 4 = ‘00100’.
- x ^ y represents the bit-wise exclusive OR operation between the binary representation of x and y: 31 ^ 4 = 27 = ‘11011’.
- x >> k represents the bit-wise right shift of x by k bits with the vacated positions at the left filled with ‘0’ bits: 61 >> 3 = 7 = ‘000111’.
- x << k represents the bit-wise left shift of x by k bits with vacated positions at the right filled with ‘0’ bits: 4 << 3 = 32 = ‘100000’.
- ++ represents an increment operator: x++ increments the value of x by 1.
- The symbols (* and *) are used to enclose comments.

9. The following are the major changes of this document with respect to "Markov Service Options for Wideband Spread Spectrum Communications Systems Rev X4 - August 04, 1997" published by Qualcomm Incorporated:

- This document applies only to base stations with P_REV equal to or greater than six, and to mobile stations with MOB_P_REV equal to or greater than six.
- Support for systems operating in MC-MAP mode was added.
- Support for all forward and reverse Fundamental Channel radio configurations was added.
- A single service option number is used.
- Notion of Rate Set 1 and Rate Set 2 were removed.
- Service option negotiation procedures and related messages were removed.

- If the base station provides a Public Long Code Mask to the mobile station, the PLCM is used for synchronization calculations; otherwise, ESN is used.
- "Traffic Channel" was changed to "Fundamental Channel".
- "Packet" was changed to "data block".

REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this Specification. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based upon this Specification are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

—*Standards:*

1. Reserved.[1]
2. *3GPP2 C.S0002-A, Physical Layer Standard for cdma2000 Spread Spectrum Systems.*
3. *3GPP2 C.S0003-A, Medium Access Control Standard for cdma2000 Spread Spectrum Systems.*
4. Reserved.[2]
5. *3GPP2 C.S0005-A, Upper Layer (Layer 3) Signaling Standard for cdma2000 Spread Spectrum Systems.*

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[1] Reserved for future use.

[2] Reserved for future use.

6. *3GPP2 C.P9003-A, Multi-Carrier Specification for Spread Spectrum on GSM MAP (MC-MAP).*

1 GENERAL

1.1 Terms

Base Station (BS). A fixed station used for communicating with mobile stations. Depending upon the context, the term base station may refer to a cell, a sector within a cell, or another part of the wireless system.

Blank-and-burst. The preemption of the traffic in an entire traffic channel frame by another form of traffic, typically signaling.

BS/MSC. The base station and mobile switching center considered as a single functional entity.

Data Block. The unit of data exchanged between the multiplex sublayer and the MSO.

Dim-and-burst. A frame in which primary traffic is multiplexed with secondary, signaling, or secondary and signaling traffic.

FER. Frame Error Rate.

Forward Fundamental Channel. A portion of a Forward Traffic Channel.

Forward Traffic channel. One or more forward CDMA channels used to transport user and signaling traffic from the base station to the mobile station (see Forward Fundamental Channel, Forward Dedicated Control Channel, and Forward Supplemental Channel).

Frame. A basic timing interval in the system. For the Fundamental channel, a frame is 20 ms long.

Fundamental Channel. A portion of a traffic channel, which includes a Forward Fundamental Channel and a Reverse Fundamental Channel.

Mobile Station (MS). A station that communicates with the base station.

Multiplex Format Indicator. A number that specifies the format of a MuxPDU [see 3].

Multiplex Option. The ability of the multiplex sublayer and lower layers to be tailored to provide special capabilities. A multiplex option defines such characteristics as the frame format and rate decision rules (see also Multiplex Sublayer).

Multiplex Sublayer. One of the conceptual layers of the system that multiplexes and demultiplexes primary traffic, secondary traffic, and signaling traffic (see [3]).

MuxPDU Type 1 Category. The category of the received MuxPDU type 1 as defined in [3].

MuxPDU Type 2 Category. The category of the received MuxPDU type 2 as defined in [3].

PER. PDU Error Rate.

Primary Traffic. Data bits from a service that has the traffic type in the Service Configuration Record set to Primary.

Radio Configuration (RC). A set of Forward Traffic Channel and Reverse Traffic Channel transmission formats that are characterized by physical layer parameters, such as transmission rates, modulation characteristics, and spreading rate.

Reverse Fundamental Channel. A portion of a Reverse Traffic Channel.

Reverse Traffic channel. One or more reverse CDMA channels on which data and signaling are transmitted from a mobile station to a base station (see Reverse Dedicated Control Channel, Reverse Fundamental Channel, and Reverse Supplemental Channel).

Secondary Traffic. Data bits from a service that has the traffic type in the Service Configuration Record set to Secondary.

Service Option. A service capability of the system. Service options may be applications such as voice, data, or facsimile etc.

Service Option Connection. A particular instance or session in which the service defined by a service option is used.

Signaling Traffic. Control messages that are carried between mobile station and the base station on the Traffic Channel.

System Time. The time reference used by the system. System Time is synchronous to Universal Coordinated Time (except for leap seconds) and uses the same time origin as GPS time. All base stations use the same System Time (within a small margin of error). Mobile stations use the same System Time, offset by the propagation delay from the base station to the mobile station.

Traffic Channel. One or more CDMA channels on which data and signaling are transmitted between a mobile station and base station (see Forward Traffic Channel and Reverse Traffic Channel).

1.2 Notation

The Markov service option uses the notation as listed in Table 1.

Table 1. Summary of Markov Service Option Notation

Parameter	Section	Name/Description
A1, B1, C1	2.9.2.1.2.2	Scaled cumulative transition probabilities
E		If the base station provides the Public Long Code Mask for the mobile station, E is set to the least significant 32 bits of the Public Long Code Mask; otherwise, E is set to the Electronic Serial Number of the mobile station (ESN)[1].
FRNG	2.9.1	State of the Forward Fundamental Channel pseudo-random number generator
NUM_RAND	2.9.3.1	Number of pseudo-random number generations per frame to generate information bits in a data block

[1] For example, when MC-MAP mode is used, the base station will provide a PLCM to the mobile station, in which case E shall be set to the least significant 32 bits of the PLCM.

R(n)	2.9.2.1.2	Data block rate for the n^{th} frame
RRNG	2.9.1	State of the Reverse Fundamental Channel pseudo-random number generator
s(n)	2.9.2.1.2	State of the Markov chain during the n^{th} frame in the variable rate mode
x_n	2.9.1	Pseudo-random number generated by the linear congruent generator
$y_n(k)$	2.9.3.1	A 24-bit pseudo-random number used for the generation of information bits
$y_n^{LE}(k)$	2.9.3.1	A number derived from $y_n(k)$ after storing it in "little endian" order
z_n	2.9.2.1.2.2	A 15-bit pseudo-random number used for determining the next transition state in the Markov chain in the variable rate mode.

No text.

2 MARKOV SERVICE OPTION

2.1 General Description

The Markov service option provides pseudo-random data for testing the Fundamental Channel between the mobile station and the base station. The test can be performed at a fixed data rate or at a variable data rate.

The mobile station and the base station generate a Markov data block for every Fundamental Channel frame. A Markov data block can be at one of four types: Rate 1, Rate 1/2, Rate 1/4, and Rate 1/8. If Multiplex Option 0x01 is used, these data blocks contain 171, 80, 40 and 16 bits respectively (for Multiplex Option 0x01 primary traffic). If Multiplex Option 0x02 is used, these data blocks contain 266, 124, 54 and 20 bits respectively (for Multiplex Option 0x02 primary traffic).

The selection of the data rate for each data block in a variable rate test is governed by a pseudo-random process. The content of each data block is also generated by a pseudo-random process. The pseudo-random processes are synchronized between the mobile station and the base station. This permits the receiving station to reproduce the transmitted data blocks and compare them to the received data blocks. The Markov service option counts the number of various frame types that were transmitted on the Fundamental Channel. The Markov service option also counts the number of various frame types received on the Fundamental Channel according to the information provided by the multiplex sublayer and the result of the comparison between the data block received and the locally generated replica. Frame error statistics can be calculated from these counts.

The Markov service option allows system signaling to take precedence. Dim-and-burst frames and blank-and-burst frames are excluded from frame error rate calculations. Because the receiver cannot predict when the transmitter sends a dim-and-burst or blank-and-burst frame, the receiver may categorize a frame as dim-and-burst or a blank-and-burst when it is not (false alarm), or categorize a frame as not dim-and-burst or blank-and-burst when it is (miss); therefore, the frame error statistics calculated by using only data block counts recorded in the receiver may not be exact; however, the error is very small and can usually be ignored. The frame error statistics calculated by using data block counts recorded in both the transmitter and the receiver will be exact if the transmitter and the receiver start and end the counting synchronously.

Since the Markov service option takes into account system signaling but not secondary traffic, in order to ensure that the data block error rate estimates the frame error rate as closely as possible, the Markov service option should not be used when another service option is using the Fundamental Channel.

2.2 Service Option Number

The Markov Service Option shall use service option number 54.

2.3 Multiplex Options

2.3.1 Required Multiplex Option Support

The MSO shall support an interface with Multiplex Options 0x01 and 0x02. Data blocks generated by MSO shall be transported as primary traffic.

2.3.2 Interfaces to the Multiplex Sublayer

2.3.2.1.1 Transmitted Data blocks

The MSO shall generate exactly one data block every 20 ms. The data block contains the service option information bits which are transmitted as primary traffic. The generated data block shall be one of five types as shown in Table 2. The number of bits for each type of data block shall be as shown in Table 2.

Unless otherwise commanded by the multiplex sublayer, the MSO shall supply either a Rate 1, Rate 1/2, Rate 1/4 or Rate 1/8 data block to the multiplex sublayer every 20 ms, for transmission on a Fundamental Channel frame. Upon command by the multiplex sublayer, the MSO shall supply a Blank data block (a data block with no bits) to the multiplex sublayer. Also upon command by the multiplex sublayer, the MSO shall truncate the generated data block to a size that is requested by the multiplex sublayer.

Table 2. Data Block Types Supplied by the MSO to the Multiplex Sublayer

Data block Type	Multiplex Option 0x01 (Bits per Data Block)	Multiples Option 0x02 (Bits per Data Block)
Rate 1	171	266
Rate 1/2	80	124
Rate 1/4	40	54
Rate 1/8	16	20
Blank	0	0

2.3.2.1.2 Received Data blocks

The multiplex sublayer in the receiving station categorizes every MuxPDU in the received Fundamental Channel frame (see [3]), and supplies the data block type and accompanying bits, if any, to MSO. The service option processes the bits of the received data block as described in 2.8.2.

2.4 Negotiation and Activation of Service Option

The mobile station shall negotiate for MSO using service configuration and negotiation procedures described in [5].

2.4.1 Mobile Station Requirements

The MSO shall be negotiated and connected using the service configuration and negotiation procedures defined in [5]. The mobile station shall not propose a service configuration with attributes different from those specified in Table 3. The mobile station shall reject any service configuration containing a Markov service option connection with attributes different from those specified in Table 3. For a mobile station operating in MC-41 mode, the mobile station shall indicate the preferred Forward Fundamental Channel radio configuration and the preferred Reverse Fundamental Channel radio configuration in the FOR_RC_PREF field and the REV_RC_PREF field, respectively, in the *Page Response Message* or the *Origination Message*. For a mobile station operating in MC-MAP mode (see [6]), the mobile station shall indicate the preferred Forward Fundamental Channel radio configuration and the preferred Reverse Fundamental Channel radio configuration in the FOR_RC_PREF field and the REV_RC_PREF field, respectively, in the *MC-MAP RRC Connection Request Message*.

Table 3. Valid Service Configuration Attributes for MSO

Service Configuration Attribute	Valid Selections
Forward Multiplex Option	0x01[1] or 0x02[2]
Reverse Multiplex Option	0x01[3] or 0x02[4]
Forward Transmission Rates	Rate 1, 1/2, 1/4, and 1/8
Reverse Transmission Rates	Rate 1, 1/2, 1/4, and 1/8
Forward FCH Radio Configuration	RC 1, 2, 3, 4, 6, 7, 8, or 9
Reverse FCH Radio Configuration	RC 1, 2, 3, 4, 5, or 6
Forward Traffic Type	Primary Traffic
Reverse Traffic Type	Primary Traffic

[1] 0x01 applies only when the Forward Fundamental Channel radio configuration is 1, 3, 4, 6, or 7.

[2] 0x02 applies only when the Forward Fundamental Channel radio configuration is 2, 5, 8, or 9.

[3] 0x01 applies only when the Reverse Fundamental Channel radio configuration is 1, 3, or 5.

[4] 0x02 applies only when the Reverse Fundamental Channel radio configuration is 2, 4, or 6.

If the mobile station originates or accepts a MSO call, then the mobile station shall perform the following:

- If the MSO call is mobile station terminated, then the mobile station shall initiate an auto-answer before entering the *Waiting for Mobile Station Answer Substate*.[1]
- The mobile station shall connect Markov service option at the action time specified in the *Service Connect Message*, the *General Handoff Direction Message*, or the *Universal Handoff Direction Message*, and shall initialize the service option as specified in 2.7.1. While the service option is connected, the MSO shall process the received data blocks in accordance with 2.8 and generate the data blocks for transmission in accordance with 2.9.

2.4.2 Base Station Requirements

The base station shall perform service negotiation for the MSO as described in [5]. The base station shall only propose service configurations with attributes as specified in Table 3. The

[1] For purposes of this specification, the term "auto-answer" shall have the following meaning: while in the *Waiting for Mobile Station Answer Substate* of the *Mobile Station Control on the Traffic Channel State*, the mobile station shall automatically send a *Connect Order* to the base station as a message requiring acknowledgment without waiting for the user to explicitly command the call to be answered. The mobile station shall enter the *Conversation Substate*.

base station should reject any service configuration with attributes different from those specified in Table 3. The base station should grant the Forward and Reverse Fundamental Channel radio configurations requested by the mobile station.

If the base station establishes a service configuration, as specified in a *Service Connect Message*, then it should wait till the action time specified in the *Service Connect Message*, before connecting and initializing the service option. While the service configuration includes this service option connection, the MSO shall process the received data blocks in accordance with 2.8 and generate the data blocks for transmission in accordance with 2.9.

2.5 Synchronization Frame

In the Markov service option, the Forward Fundamental Channel and Reverse Fundamental Channel are each subdivided into independent segments of 512 frames (10.24 seconds). The first frame of a segment is called the synchronization frame. All pseudo-random number generators associated with the channel are re-initialized prior to data block processing for each synchronization frame. All service option initialization and control operations also take effect immediately prior to data block processing for a synchronization frame.

If the base station provides the Public Long Code Mask to the mobile station, E shall be set to the least significant 32 bits of the Public Long Code Mask; otherwise, E shall be set to the Electronic Serial Number of the mobile station (ESN).

The Forward Fundamental Channel synchronization frames shall be those frames for which the least significant nine bits of the System Time in frames (as defined in [2]) are equal to the least significant nine bits of the bit-wise exclusive-OR of E and the value 0x2AAAAAAA, The Reverse Fundamental Channel synchronization frames shall be those frames for which the least significant nine bits of the System Time in frames (as defined in [2]) are equal to the least significant nine bits of the bit-wise exclusive-OR of the E and the value 0x55555555.

2.6 Counters

The mobile station shall support the transmit counters listed in Table 4.

Table 4. Transmit Frame Counters Maintained by the Mobile Station

Generated Data Block Type	Transmitted Frame Type	Counter Name
Rate 1	Rate 1 with no signaling	MSO_E1_T1
Rate 1/2	Rate 1/2 with no signaling	MSO_E2_T2
Rate 1/4	Rate 1/4 with no signaling	MSO_E4_T4
Rate 1/8	Rate 1/8 with no signaling	MSO_E8_T8
Rate 1	Rate 1 with dim-and-burst signaling	MSO_E1_TD
Rate 1/2	Rate 1/2 with dim-and-burst signaling	MSO_E2_TD

Rate 1/4	Rate 1/4 with dim-and-burst signaling	MSO_E4_TD
Rate 1/8	Rate 1/8 with dim-and-burst signaling	MSO_E8_TD
Rate 1	Rate 1 with blank-and-burst signaling	MSO_E1_TB
Rate 1/2	Rate 1/2 with blank-and-burst signaling	MSO_E2_TB
Rate 1/4	Rate 1/4 with blank-and-burst signaling	MSO_E4_TB
Rate 1/8	Rate 1/8 with blank-and-burst signaling	MSO_E8_TB

The mobile station shall support the receive counters listed in Table 5 and Table 6.

Table 5. Receive Frame Counters Maintained by the Mobile Station (Part 1 of 2)

Expected Data Block Type	Received Frame Type	Counter Name
Rate 1	Error free Rate 1 frame with no dim-and-burst	MSO_E1_R1
Rate 1	Dim-and-burst frame	MSO_E1_RD
Rate 1	Blank-and-burst frame	MSO_E1_RB
Rate 1	Rate 1/2 frame with no dim-and-burst	MSO_E1_R2
Rate 1	Rate 1/4 frame with no dim-and-burst	MSO_E1_R4
Rate 1	Rate 1/8 frame with no dim-and-burst	MSO_E1_R8
Rate 1	Rate 1 physical layer frame with insufficient physical layer frame quality*	MSO_E1_RFL
Rate 1	Insufficient frame quality (erasure)	MSO_E1_RE
Rate 1	Rate 1 with bit errors detected by the Markov service option	MSO_E1_RERR
Rate 1/2	Error free Rate 1/2 frame with no dim-and-burst	MSO_E2_R2
Rate 1/2	Dim-and-burst frame	MSO_E2_RD
Rate 1/2	Blank-and-burst frame	MSO_E2_RB
Rate 1/2	Rate 1 frame with no dim-and-burst	MSO_E2_R1
Rate 1/2	Rate 1/4 frame with no dim-and-burst	MSO_E2_R4
Rate 1/2	Rate 1/8 frame with no dim-and-burst	MSO_E2_R8
Rate 1/2	Rate 1 physical layer frame with insufficient physical layer frame quality*	MSO_E2_RFL
Rate 1/2	Insufficient frame quality (erasure)	MSO_E2_RE
Rate 1/2	Rate 1/2 with bit errors detected by the Markov service option	MSO_E2_RERR
Rate 1/4	Error free Rate 1/4 frame with no dim-and-burst	MSO_E4_R4
Rate 1/4	Dim-and-burst frame	MSO_E4_RD
Rate 1/4	Blank-and-burst frame	MSO_E4_RB
Rate 1/4	Rate 1 frame with no dim-and-burst	MSO_E4_R1
Rate 1/4	Rate 1/2 frame with no dim-and-burst	MSO_E4_R2
Rate 1/4	Rate 1/8 frame with no dim-and-burst	MSO_E4_R8
Rate 1/4	Rate 1 physical layer frame with insufficient physical layer frame quality*	MSO_E4_RFL
Rate 1/4	Insufficient frame quality (erasure)	MSO_E4_RE

Rate 1/4	Rate 1/4 with bit errors detected by the Markov service option	MSO_E4_RERR

Table 6. Receive Frame Counters Maintained by the Mobile Station (Part 2 of 2)

Expected Data Block Type	Received Frame Type	Counter Name
Rate 1/8	Error free Rate 1/8 frame with no dim-and-burst	MSO_E8_R8
Rate 1/8	Dim-and-burst frame	MSO_E8_RD
Rate 1/8	Blank-and-burst frame	MSO_E8_RB
Rate 1/8	Rate 1 frame with no dim-and-burst	MSO_E8_R1
Rate 1/8	Rate 1/2 frame with no dim-and-burst	MSO_E8_R2
Rate 1/8	Rate 1/4 frame with no dim-and-burst	MSO_E8_R4
Rate 1/8	Rate 1 physical layer frame with insufficient physical layer frame quality*	MSO_E8_RFL
Rate 1/8	Insufficient frame quality (erasure)	MSO_E8_RE
Rate 1/8	Rate 1/8 with bit errors detected by the Markov service option	MSO_E8_RERR

*Categorized by Multiplex Option 0x01 only.

The RTC_BUFFER in the mobile, shall be capable of storing the transmit counter values shown in Table 4. The FTC_BUFFER in the mobile, shall be capable of storing the receive counter values shown in Table 5.

The mobile station shall retain the counters and the buffer values while the Markov service option is connected.

2.7 Mobile Station Initialization and Control Operations

2.7.1 Service Option Initialization

If a Markov service option initialization is required as a result of a Forward Traffic Channel message, the mobile station shall consider the System Time in frames coinciding with the action time of the message (as defined in [5]) to be the effective initialization frame, EFF_FRAME. If a Markov service option initialization is required as a result of some other event, the mobile station shall designate some System Time in frames to be EFF_FRAME, and should designate the System Time in frames most closely corresponding to that event to be EFF_FRAME.

To perform Markov service option initialization, the mobile station shall perform the following operations:

- Immediately prior to Markov data block processing for the Reverse Fundamental Channel synchronization frame for which the System Time in frames falls in the range from EFF_FRAME to EFF_FRAME + 511, inclusive, the mobile station shall set the counters associated with the Reverse Fundamental Channel and the counters in RTC_BUFFER to zero.

- Immediately prior to Markov data block processing for the Forward Fundamental Channel synchronization frame for which the System Time in frames falls in the range from EFF_FRAME to EFF_FRAME + 511, inclusive, the mobile station shall set the counters associated with the Forward Fundamental Channel and the counters in FTC_BUFFER to zero.

2.7.2 Mobile Station Control Operations

2.7.2.1 Control Invocation

The base station can use the *Service Option Control Message* for invoking service option specific directives. If the mobile station supports *Service Option Control Message*, the base station should use *Service Option Control Message* for invoking service option specific directives.

When the base station sends the *Service Option Control Message*, it shall send it as a message requiring acknowledgment.

2.7.2.2 Control Directive

When the mobile station receives a *Service Option Control Message* with CTL_REC_TYPE equal to '00000000', the mobile station shall consider the System Time in frames coinciding with the action time of the message to be the effective operation frame, EFF_FRAME.

Immediately prior to Markov data block processing for the Reverse Fundamental Channel synchronization frame for which the System Time in frames falls in the range from EFF_FRAME to EFF_FRAME + 511, inclusive, the mobile station shall:

- If the COPY_COUNTERS field of the message was equal to '1', copy the counters associated with the Reverse Fundamental Channel to RTC_BUFFER (see 2.6).
- If the CLEAR_COUNTERS field of the message was equal to '1', set the counters associated with the Reverse Fundamental Channel (see 2.8.1) to zero.
- Set RTC_MODE to the value of the TEST_MODE field of the message.

Immediately prior to Markov data block processing for the Forward Fundamental Channel synchronization frame for which the System Time in frames falls in the range from EFF_FRAME to EFF_FRAME + 511, inclusive, the mobile station shall:

- If the COPY_COUNTERS field of the message was equal to '1', copy the counters associated with the Forward Fundamental Channel to FTC_BUFFER (see 2.6).
- If the CLEAR_COUNTERS field of the message was equal to '1', set the counters associated with the Forward Fundamental Channel (see 2.8.2) to zero.
- Set FTC_MODE to the value of the TEST_MODE field of the message.

2.7.2.3 Counter Retrieval

When the mobile station receives a *Service Option Control Message*[1] with CTL_REC_TYPE equal to '00000001', then at the action time associated with the message, the mobile station shall respond with the Service *Option Control Message* containing the mobile station response shown in Table 7 corresponding to the VECT_COUNTER_ID field in the received *Service Option Control Message*.

Table 7. Correspondence between the VECT_COUNTER_ID Field and the Mobile Station Response

VECT_COUNTER_ID	Mobile Station Response	Reference Section
'00000000'	*FER Counters Response*	3.2.1
'00000001'	*Same Rate Received Counters Response*	3.2.2
'00000010'	*Same Rate Transmitted Counters Response*	3.2.3
'00000011'	*Transmitted Counters Response*	3.2.4
'00000100'	*Rate 1 Expected Counters Response*	3.2.5

[1] Due to format limitations, *Service Option Control Order* can not be used for the retrieval of counter values from the mobile station.

‘00000101’	*Rate 1/2 Expected Counters Response*	3.2.6
‘00000110’	*Rate 1/4 Expected Counters Response*	3.2.7
‘00000111’	*Rate 1/8 Expected Counters Response*	3.2.8

If VECT_COUNTER_ID is not equal to a value defined in Table 7, the mobile station shall send a *Mobile Station Reject Order* with ORDQ field set to ‘00000100’.

2.8 Data Block Processing

The service option shall perform receive and transmit data block processing exactly once for every 20 ms frame of System Time while the service option is connected.

2.8.1 Transmit Data Block Processing

Transmit data block processing (Forward Fundamental Channel data block processing in the base station or Reverse Fundamental Channel data block processing in the mobile station) consists of the following procedures:

- The service option shall generate a data block as specified in 2.9, for the System Time in frames corresponding to the System Time at which this frame will be transmitted.
- If the multiplex sublayer has requested a Blank data block, the service option shall discard the generated data block and supply a blank data block to the multiplex sublayer.
- If the multiplex sublayer has requested a non-blank x-bit data block, the service option shall supply the first x bits of the generated data block to the multiplex sublayer.
- The service option shall increment the counter shown in Table 8 corresponding to the rate of the generated data block and the command received from the multiplex sublayer.

Table 8. Counters for Transmitted Frames

Rate of Generated Data Block	Multiplex Sublayer Command	Counter Incremented
1	None	MSO_E1_T1
1/2	None	MSO_E2_T2
1/4	None	MSO_E4_T4
1/8	None	MSO_E8_T8
1	Max Rate = Rate 1/2	MSO_E1_TD
1/2	Max Rate = Rate 1/2	MSO_E2_TD
1/4	Max Rate = Rate 1/2	MSO_E4_TD

1/8	Max Rate = Rate 1/2	MSO_E8_TD
1	Blank	MSO_E1_TB
1/2	Blank	MSO_E2_TB
1/4	Blank	MSO_E4_TB
1/8	Blank	MSO_E8_TB

2.8.2 Receive Data block Processing

Receive data block processing (Forward Fundamental Channel data block processing in the mobile station or Reverse Fundamental Channel data block processing in the base station) consists of the following procedures:

- The service option shall generate a data block as specified in 2.9 for the System Time in frames for this frame.
- The service option shall accept a received frame and a categorization of the MuxPDU (see [3]) from the multiplex sublayer. If the categorization of the received MuxPDU corresponds to the rate of the generated data block, the service option shall compare the contents of the generated data block with the contents of the received data block and shall determine whether they are identical.
- The service option shall increment the counter shown in Table 9 and Table 10 (when Multiplex Option in use is 0x01) or Table 11 and Table 12 (when Multiplex Option in use is 0x02) corresponding to the rate of the generated data block, the categorization of the received MuxPDU, and the result, if any, of the comparison of the data blocks. When the multiplex format indicator is supplied by the mux sublayer, the value of the multiplex format indicator shall be used as the MuxPDU category.

Table 9. Counter Updates for Received Frames for MSO when Multiplex Option in use is 0x01 (Part 1 of 2)

Rate of Generated Data Block	Category of Received MuxPDU	Data Block Comparison Identical?	Counter to Increment
1	1	Y	MSO_E1_R1
1	1	N	MSO_E1_RERR
1	2, 3, 4,11,12,13	N/A	MSO_E1_RD
1	5,14	N/A	MSO_E1_RB
1	6	N/A	MSO_E1_R2
1	7	N/A	MSO_E1_R4
1	8	N/A	MSO_E1_R8
1	9	N/A	MSO_E1_RFL
1	10	N/A	MSO_E1_RE

1/2	1	N/A	MSO_E2_R1
1/2	2, 3, 4,11,12,13	N/A	MSO_E2_RD
1/2	5,14	N/A	MSO_E2_RB
1/2	6	Y	MSO_E2_R2
1/2	6	N	MSO_E2_RERR
1/2	7	N/A	MSO_E2_R4
1/2	8	N/A	MSO_E2_R8
1/2	9	N/A	MSO_E2_RFL
1/2	10	N/A	MSO_E2_RE
1/4	1	N/A	MSO_E4_R1
1/4	2,3,4,11,12,13	N/A	MSO_E4_RD
1/4	5,14	N/A	MSO_E4_RB
1/4	6	N/A	MSO_E4_R2
1/4	7	Y	MSO_E4_R4
1/4	7	N	MSO_E4_RERR
1/4	8	N/A	MSO_E4_R8
1/4	9	N/A	MSO_E4_RFL
1/4	10	N/A	MSO_E4_RE

Table 10. Counter Updates for Received Frames for MSO when Multiplex Option in use is 0x01 (Part 2 of 2)

Rate of Generated Data Block	Category of Received MuxPDU	Data Block Comparison Identical?	Counter to Increment
1/8	1	N/A	MSO_E8_R1
1/8	2,3,4,11,12,13	N/A	MSO_E8_RD
1/8	5,14	N/A	MSO_E8_RB
1/8	6	N/A	MSO_E8_R2
1/8	7	N/A	MSO_E8_R4
1/8	8	Y	MSO_E8_R8
1/8	8	N	MSO_E8_RERR
1/8	9	N/A	MSO_E8_RFL
1/8	10	N/A	MSO_E8_RE

Table 11. Counter Updates for Received Frames for MSO when Multiplex Option in use is 0x02 (Part 1 of 2)

Rate of Generated Data Block	Category of Received MuxPDU	Data Block Comparison Identical?	Counter to Increment
1	1	Y	MSO_E1_R1
1	1	N	MSO_E1_RERR
1	2, 3, 4,6,7,8,10,12, 13,15,16,18, 20,22	N/A	MSO_E1_RD
1	5,9,14,17,21,23,25	N/A	MSO_E1_RB
1	11	N/A	MSO_E1_R2
1	19	N/A	MSO_E1_R4
1	24	N/A	MSO_E1_R8
1	26	N/A	MSO_E1_RE
1/2	1	N/A	MSO_E2_R1
1/2	2, 3, 4,6,7,8,10,12, 13,15,16,18, 20,22	N/A	MSO_E2_RD
1/2	5,9,14,17,21,23,25	N/A	MSO_E2_RB
1/2	11	Y	MSO_E2_R2
1/2	11	N	MSO_E2_RERR
1/2	19	N/A	MSO_E2_R4
1/2	24	N/A	MSO_E2_R8
1/2	26	N/A	MSO_E2_RE

Table 12. Counter Updates for Received Frames for MSO when Multiplex Option in use is 0x02 (Part 2 of 2)

Rate of Generated Data Block	Category of Received MuxPDU	Data Block Comparison Identical?	Counter to Increment
1/4	1	N/A	MSO_E4_R1
1/4	2, 3, 4,6,7,8,10,12, 13,15,16,18, 20,22	N/A	MSO_E4_RD
1/4	5,9,14,17,21,23,25	N/A	MSO_E4_RB
1/4	11	N/A	MSO_E4_R2
1/4	19	Y	MSO_E4_R4
1/4	19	N	MSO_E4_RERR
1/4	24	N/A	MSO_E4_R8
1/4	26	N/A	MSO_E4_RE
1/8	1	N/A	MSO_E8_R1
1/8	2, 3, 4,6,7,8,10,12, 13,15,16,18, 20,22	N/A	MSO_E8_RD
1/8	5,9,14,17,21,23,25	N/A	MSO_E8_RB
1/8	11	N/A	MSO_E8_R2
1/8	19	N/A	MSO_E8_R4
1/8	24	Y	MSO_E8_R8
1/8	24	N	MSO_E8_RERR
1/8	26	N/A	MSO_E8_RE

2.9 Data Block Generation

Pseudo-random number generators are utilized for data block generation. These generators are initialized at every synchronization frame. The pseudo-random number generators are iterated one or more times for every frame. All the iterations of the pseudo-random number generators are used for information bit generation. In a variable rate mode, the first iterated output of the pseudo-random number generator is also used for rate selection.

The default test mode for the Markov service option is the variable rate mode (see 2.9.2.1).

2.9.1 Pseudo-random Number Generation

A Markov service option uses two independent pseudo-random number generators. One pseudo-random number generator is associated with the Forward Fundamental Channel, while the other is associated with the Reverse Fundamental Channel. These pseudo-random number generators are synchronized with their counterparts at the other end of the link as shown in Figure 1. The pseudo-random number generator for the transmit side is used for selecting the data block rate along with generating the bit stream that constitutes the transmit data block. The receive side pseudo-random number generator, by emulating the data block generation process at the other end of the link, enables the service option to verify if a data block is received error free.

The pseudo-random number generators use the linear congruent relationship

$$x_n = a \times x_{n-1} \bmod m, \qquad (2.9.1\text{-}1)$$

where $a = 7^5 = 16807$, and $m = 2^{31} - 1 = 2147483647$; x_{n-1} and x_n are the successive outputs of the generator and are 31-bit integers.

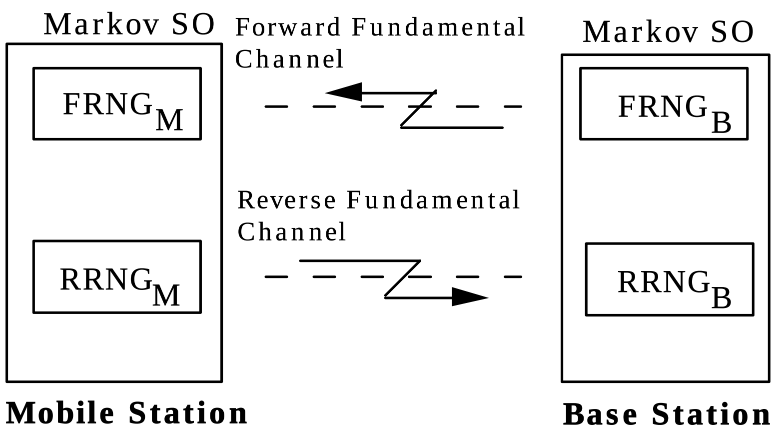

Figure 1. Synchronized Operation of Pseudo-Random Number Generators.

The service option shall store the state of the Forward Fundamental Channel pseudo-random number generator, FRNG, and the state of the Reverse Fundamental Channel pseudo-random number generator, RRNG.

2.9.1.1 Initialization

Prior to data block generation for every Forward Fundamental Channel synchronization frame, the service option shall initialize the Forward Fundamental Channel pseudo-random number generator as follows:

```
{
    a = 16807
    m = 2147483647
    FRNG = System Time in frames of the forward synchronization frame
    FRNG = (FRNG ^ 0x2AAAAAAA) & 0x7FFFFFFF
    FRNG = (FRNG * a) mod m
    FRNG = (FRNG * a) mod m
    FRNG = (FRNG * a) mod m
```

```
    FRNG = (FRNG * a) mod m
}
```

Prior to data block generation for every Reverse Fundamental Channel synchronization frame, the service option shall initialize the Reverse Fundamental Channel pseudo-random number generator as follows:

```
{
    a = 16807
    m = 2147483647
    RRNG = System Time in frames of the reverse synchronization frame
    RRNG = (RRNG ^ 0x55555555) & 0x7FFFFFFF
    RRNG = (RRNG * a) mod m
    RRNG = (RRNG * a) mod m
    RRNG = (RRNG * a) mod m
    RRNG = (RRNG * a) mod m
}
```

2.9.1.2 Number Production

Whenever a pseudo-random number is required for Forward Fundamental Channel data block processing, the service option shall use the current value of FRNG as the pseudo-random number, and then update FRNG as follows:

```
{
    a = 16807
    m = 2147483647
    FRNG = (FRNG * a) mod m
}
```

Whenever a pseudo-random number is required for Reverse Fundamental Channel data block processing, the service option shall use the current value of RRNG as the pseudo-random number, and then update RRNG as follows:

```
{
    a = 16807
    m = 2147483647
    RRNG = (RRNG * a) mod m
}
```

2.9.2 Rate Selection

2.9.2.1 Variable Rate Mode

2.9.2.1.1 Operation Prior to the First Synchronization Frame

From the time of service option connection until the first synchronization frame, the service option should generate Rate 1/8 data blocks comprised of arbitrary data.

2.9.2.1.2 Operation Commencing with the First Synchronization Frame

Commencing with the first synchronization frame, the Markov service option shall choose a data block rate every 20 ms. The data block rate is based upon state transitions in a first-order Markov model. A state in this model is defined by the rates for the current and the previous data block. With four possible data block rates Markov chain has 16 states as shown in Table 13. In this Markov chain each state transitions to one of four states. For example, state 0 can transition to state 0, 1, 2, or 3 only; and state 1 can transition to states 4, 5, 6, or 7 only. In general, if the state during frame n-1, s(n-1), is equal to k, then the state during frame n, s(n) shall satisfy the constraint

$$s(n) \in \{ (4\times k) \bmod 16, (4\times k+1) \bmod 16, (4\times k+2) \bmod 16, (4\times k+3) \bmod 16 \}.$$

Once new state s(n) is chosen, the corresponding data block rate, R(n), is given by

$$R(n) = \frac{1}{2^{(s(n) \bmod 4)}} \qquad (2.9.2.1.2\text{-}1)$$

Table 13. Definition of States in the 16-State First Order Markov Chain

s(n)	R(n-1)	R(n)
0	1	1
1	1	1/2
2	1	1/4
3	1	1/8
4	1/2	1
5	1/2	1/2
6	1/2	1/4
7	1/2	1/8
8	1/4	1
9	1/4	1/2
10	1/4	1/4
11	1/4	1/8
12	1/8	1
13	1/8	1/2
14	1/8	1/4
15	1/8	1/8

2.9.2.1.2.1 Markov Chain Initialization

Prior to data block processing for every Forward Fundamental Channel synchronization frame, the service option shall set the state of the Forward Fundamental Channel Markov chain to 15.

Prior to data block processing for every Reverse Fundamental Channel synchronization frame, the service option shall set the state of the Reverse Fundamental Channel Markov chain to 15.

2.9.2.1.2.2 Rate Selection Procedure

For every Fundamental Channel frame including the synchronization frame, the Markov service option shall use the present state FRNG or RRNG of the associated pseudo-random number generator (see 2.9.1 and 2.9.1.2) to generate two numbers, a 24-bit number $y_n(1)$ and a 15-bit number z_n. $y_n(1)$ shall be used for the generation of information bits in a data block (see 2.9.3). z_n shall be used for selecting the next state in the associated Markov chain. $y_n(1)$ and z_n shall be generated using the pseudo code as follows:

```
{
    TMPVAR = RRNG or FRNG (* use the current state of the associated pseudo-random
    number generator and update as specified in 2.9.1.2 *)
```

```
    y_n(1) = TMPVAR >> 7  (* used for information bit generation (see 2.9.3) *)
    z_n = y_n(1) & 0x7FFF  (* taking the 15 LSBs of y_n(1)*)
}
```

z_n shall be used in conjunction with Table 14 to compute the next transition state s(n) in the associated Markov chain. In this table, s(n-1), is the present state of the associated Markov chain and A1, B1 and C1 are scaled cumulative transition probabilities. These transition probabilities were selected to approximate voice activity in a typical telephone conversation. The next transition state s(n) in the associated Markov chain shall be computed using the pseudo code as follows:

```
{
    if(z_n < A1)
        s(n) = (4*s(n-1)+3) mod 16
    elseif(A1 ≤ z_n < B1)
        s(n) = (4*s(n-1)+2) mod 16
    elseif(B1 ≤ z_n < C1)
        s(n) = (4*s(n-1)+1) mod 16
    elseif(z_n ≥ C1)
        s(n) = (4*s(n-1)) mod 16
    endif
}
```

Table 14. Cumulative Transition Probabilities for a Variable Rate Test

	Scaled Cumulative Transition Probability		
s(n-1)	**A1**	**B1**	**C1**
0	0	0	2916
1	0	20906	25264
2	0	0	0
3	0	0	0
4	0	0	4915
5	0	17170	24969
6	21856	25887	27099
7	0	0	0
8	0	0	4522
9	0	5472	16384
10	21856	21856	24576
11	28246	29622	30802
12	0	0	5472
13	0	6554	6554
14	28377	28934	29491
15	29753	32473	32571

2.9.2.2 Fixed Rate Modes

In fixed rate modes, the Markov chain model for data block rate selection is not utilized.

The service option shall generate Forward Fundamental Channel data blocks of the rate shown in Table 15corresponding to the value of FTC_MODE. The service option shall generate Reverse Fundamental Channel data block of the rate shown in Table 15 corresponding to the value of RTC_MODE.

Table 15. Fixed Rate Modes

FTC_MODE or RTC_MODE	Data Block Rate
‘001’	Rate 1/8
‘010’	Rate 1/4
‘011’	Rate 1/2
‘100’	Rate 1

2.9.3 Information Bit Generation

For every Forward or Reverse Fundamental Channel frame, the Markov service option iterates the associated pseudo-random number generator one or more times as specified in the following subsections.

2.9.3.1 Procedure for Generating Information Bits for Multiplex Option 0x01

To generate a data block at any rate R(n), the service option shall generate (as specified in 2.9.2.1.2) a total of NUM_RAND pseudo-random numbers as shown in Table 16 corresponding to rate R(n).

Table 16. Required Number of Pseudo-Random Numbers per frame

Data Block Rate **R(n)**	**Required Number of Pseudo-Random Numbers** **NUM_RAND**
Rate 1	7
Rate 1/2	4
Rate 1/4	2
Rate 1/8	1

Each invocation of the pseudo-random number generator provides 24 information bits, $y_n(k)$, as follows:

```
{
    TMPVAR = RRNG or FRNG (* use the present state of the associated pseudo-random
    number generator and update as specified in 2.9.1.2*)
    yn(k) = ( TMPVAR >> 7 )
}
```

This results in a total of NUM_RAND 24-bit numbers, $y_n(1)$ through $y_n(\text{NUM\_RAND})$. If a variable mode rate is active, $y_n(1)$ is already generated during the rate selection procedure (see 2.9.2.1.2.2). Each 24-bit number $y_n(k)$, $1 \le k \le \text{NUM\_RAND}$, shall be reshuffled and stored in the "little-endian" order as shown in Figure 2. The reshuffled number $y_n^{LE}(k)$ has the least significant byte of $y_n(k)$ in the most significant byte position and *vice versa*.

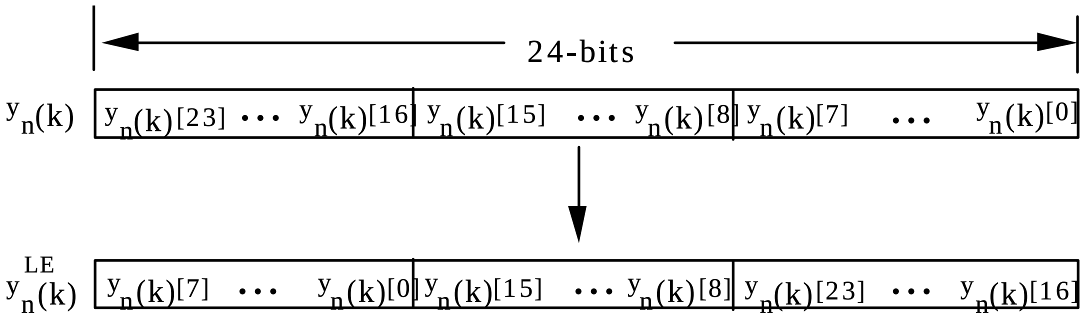

Figure 2. Reshuffling of $y_n(k)$ to Generate $y_n^{LE}(k)$

Table 17. Procedure for Generating the Data Contents of Data Blocks

Data Block Rate R(n)	Pseudo-Random Bits Generated	Bits Discarded	'0' bits Appended
1	7 × 24 = 168	0	3
1/2	4 × 24 = 96	16	0
1/4	2 × 24 = 48	8	0
1/8	1 × 24 = 24	8	0

The 171 bits in a Rate 1 data block shall be comprised of $y_n^{LE}(1)$ through $y_n^{LE}(7)$ with three '0' bits appended at the end as follows:

$$y_n^{LE}(1), y_n^{LE}(2), y_n^{LE}(3), y_n^{LE}(4), y_n^{LE}(5), y_n^{LE}(6), y_n^{LE}(7), \text{ '000'}$$

The 80 bits in a Rate 1/2 data block shall be comprised of $y_n^{LE}(1)$ through $y_n^{LE}(3)$ and the most significant byte of $y_n^{LE}(4)$ as follows:

$$y_n^{LE}(1), y_n^{LE}(2), y_n^{LE}(3), 'y_n^{LE}(4)[23]y_n^{LE}(4)[22]...y_n^{LE}(4)[17]y_n^{LE}(4)[16]'$$

The 40 bits in a Rate 1/4 data block shall be comprised of $y_n^{LE}(1)$ and the two most significant bytes of $y_n^{LE}(2)$ as follows:

$$y_n^{LE}(1), 'y_n^{LE}(2)[23]y_n^{LE}(2)[22]...y_n^{LE}(2)[9]y_n^{LE}(2)[8]'$$

The 16 bits in a Rate 1/8 data block shall be comprised of the two most significant bytes of $y_n^{LE}(1)$ as follows:

$$'y_n^{LE}(1)[23]y_n^{LE}(1)[22]...y_n^{LE}(1)[9]y_n^{LE}(1)[8]'$$

2.9.3.2 Procedure for Generating Information bits for Multiplex Option 0x02

To generate a data block at any rate R(n), the service option shall generate (as specified in 2.9.1.2) a total of NUM_RAND pseudo-random numbers as shown in Table 18 corresponding to rate R(n).

Table 18. Required Number of Pseudo-Random Numbers per frame

Data Block Rate R(n)	Required Number of Pseudo-Random Numbers NUM_RAND
Rate 1	11
Rate 1/2	6
Rate 1/4	3
Rate 1/8	1

Each invocation of the pseudo-random number generator provides 24 information bits, $y_n(k)$, as follows:

{

TMPVAR = RRNG or FRNG (* use the present state of the associated pseudo-random number generator and update as specified in 2.9.1.2*)

$y_n(k)$ = (TMPVAR >> 7)

}

This results in a total of NUM_RAND 24-bit numbers, $y_n(1)$ through $y_n(\text{NUM\_RAND})$. If a variable mode rate is active, $y_n(1)$ is already generated during the rate selection procedure (see 2.9.2.1.2.2). Each 24-bit number $y_n(k)$, $1 \le k \le \text{NUM\_RAND}$ shall be reshuffled to generate $y_n^{LE}(k)$ as shown in Figure 2.

Table 19. Procedure for Generating the Data Contents of Data Blocks

Data Block Rate R(n)	Pseudo-Random Bits Generated	Bits Discarded	'0' bits Appended
1	11 × 24 = 264	0	2
1/2	6 × 24 = 144	20	0
1/4	3 × 24 = 72	18	0
1/8	1 × 24 = 24	4	0

The 266 bits in a Rate 1 data block shall be comprised of $y_n^{LE}(1)$ through $y_n^{LE}(11)$ with two '0' bits appended at the end as follows:

$$y_n^{LE}(1), y_n^{LE}(2), y_n^{LE}(3), y_n^{LE}(4), y_n^{LE}(5), y_n^{LE}(6), y_n^{LE}(7), y_n^{LE}(8), y_n^{LE}(9), y_n^{LE}(10), y_n^{LE}(11), \text{`00'}$$

The 124 bits in a Rate 1/2 data block shall be comprised of $y_n^{LE}(1)$ through $y_n^{LE}(5)$ and the most significant four bits of $y_n^{LE}(6)$ appended at the end as follows:

$$y_n^{LE}(1), y_n^{LE}(2), y_n^{LE}(3), y_n^{LE}(4), y_n^{LE}(5), \text{'}\, y_n^{LE}(6)[23] y_n^{LE}(6)[22] y_n^{LE}(6)[21] y_n^{LE}(6)[20]\text{'}$$

The 54 bits in a Rate 1/4 data block shall be comprised of $y_n^{LE}(1)$, $y_n^{LE}(2)$ and the most significant six bits of $y_n^{LE}(3)$ appended at the end as follows:

$$y_n^{LE}(1), y_n^{LE}(2), 'y_n^{LE}(3)[23]y_n^{LE}(3)[22]y_n^{LE}(3)[21]y_n^{LE}(3)[20]y_n^{LE}(3)[19]y_n^{LE}(3)[18]'$$

The 20 bits in a Rate 1/8 data block shall be comprised of the most significant 20 bits of $y_n^{LE}(1)$ as follows:

$$'y_n^{LE}(1)[23]y_n^{LE}(1)[22]\ldots y_n^{LE}(1)[5]y_n^{LE}(1)[4]'$$

No text.

3 MESSAGE FORMATS

This section describes the message formats for Markov service option specific messages.

3.1 Base Station Message Formats

3.1.1 Service Option Control Message

If the base station sends a *Service Option Control Message*, it shall set the CTL_REC_TYPE field to the value shown in Table 20 corresponding to the desired directive.

Table 20. CTL_REC_TYPE Codes

CTL_REC_TYPE	Type of Directive
‘00000000’	Control Directive
‘00000001’	Counter Retrieval Directive
'00000010' - '11111111'	Reserved

3.1.1.1 Control

When the base station sends a *Service Option Control Message* to invoke control action in a mobile, it shall include the Type-specific fields as specified in Table 21.

Table 21. Service Option Control Message Type-specific Fields

Field	Length (bits)
CTL_REC_TYPE (‘00000000’)	8
TEST_MODE	3
COPY _COUNTERS	1
CLEAR_COUNTERS	1
RESERVED	3

CTL_REC_TYPE — Control record type field.

The base station shall set this field to ‘00000000’ to signify a control directive.

TEST_MODE — Test Mode field.

The base station shall set this field to the TEST_MODE value shown in Table 22 corresponding to the rate at which data blocks should be generated for the Markov call.

COPY_COUNTERS — Copy Counters field.

If the mobile station is to copy the counter values at the next synchronization frame (see 2.5), the base station shall set this field to ‘1’; otherwise, the base station shall set this field to ‘0’.

CLEAR_COUNTERS — Clear Counters field.

If the mobile station is to clear the counters at the next synchronization frame (see 2.5), the base station shall set this field to ‘1’; otherwise, the base station shall set this field to ‘0’.

RESERVED — Reserved bits.

The base station shall set this field to ‘000’.

Table 22. TEST_MODE Codes

TEST_MODE	Test Rate
‘000’	Variable rate
‘001’	Rate 1/8
‘010’	Rate 1/4
‘011’	Rate 1/2
‘100’	Rate 1

3.1.1.2 Counter Retrieval

When the base station sends a *Service Option Control Message* to retrieve counter values from the mobile, it shall include the Type-specific fields as specified in Table 23.

Table 23. Type-specific Fields in a Service Option Control Message used for Counter Retrieval from the Mobile Station.

Field	Length (bits)
CTL_REC_TYPE (‘00000001’)	8
VECT_COUNTER_ID	8

CTL_REC_TYPE — Control record type field.

The base station shall set this field to ‘00000001’ to signify counter retrieval directive.

VECT_COUNTER_ID — Vector counter identification field.

The base station shall set this field to correspond to the value shown in Table 24 corresponding to the desired vector of counter values.

Table 24. VECT_COUNTER_ID Codes

VECT_COUNTER_ID	Vector Name
‘00000000’	FER Counters
‘00000001’	Same Rate Received Counters
‘00000010’	Same Rate Transmitted Counters
‘00000011’	Transmitted Counters
‘00000100’	Rate 1 Expected Counters
‘00000101’	Rate 1/2 Expected Counters
‘00000110’	Rate 1/4 Expected Counters
‘00000111’	Rate 1/8 Rate Expected Counters
'00001000' - '11111111'	Reserved

3.2 Mobile Station Message Formats

3.2.1 FER Counters Response

When the mobile station sends an *FER Counters Response*, it shall include the following Type-specific fields in the *Service Option Control Message:*

Table 25. Type-specific Fields in a Service Option Control Message corresponding to FER Counters Response

Field	Length (bits)
CTL_REC_TYPE (‘00000001’)	8
VECT_COUNTER_ID (‘00000000’)	8
MSO_E1_R1	24
MSO_Ex_Rx	24
MS0_E1_RBAD	24
MSO_Ex_RBAD	24

CTL_REC_TYPE — Control record type field.

The mobile station shall set this field to ‘00000001’.

VECT_COUNTER_ID — Vector counter identification field.

The mobile station shall set this field to ‘00000000’.

MSO_E1_R1 — Counter for the number of Rate 1 frames received error free.

The mobile station shall set this field to the value of MSO_E1_R1 stored in the FTC_BUFFER modulo 2^{24}.

MSO_Ex_Rx — Number of Rate x frames received error free.

The mobile station shall compute this value using counter values stored in the FTC_BUFFER as follows:
MSO_Ex_Rx = (MSO_E1_R1+MSO_E2_R2+MSO_E4_R4+ MSO_E8_R8) mod 2^{24}.

MSO_E1_RBAD — Number of Rate 1 data blocks received in error.

The mobile station shall compute this value using counter values stored in the FTC_BUFFER as follows:
MSO_E1_RBAD = (MSO_E1_R2 + MSO_E1_R4 + MSO_E1_R8 + MSO_E1_RFL + MSO_E1_RE + MSO_E1_RERR) mod 2^{24}.

MSO_Ex_RBAD — Number of Bad overall data blocks.

The mobile station shall compute this value using counter values stored in the FTC_BUFFER as follows:

MSO_Ex_RBAD = (MSO_E2_R1 + MSO_E2_R4 +
MSO_E2_R8 + MSO_E2_RFL +
MSO_E2_RE + MSO_E2_RERR+
MSO_E4_R1 + MSO_E4_R2+
MSO_E4_R8 + MSO_E4_RFL +
MSO_E4_RE + MSO_E4_RERR+
MSO_E8_R1 + MSO_E8_R2+
MSO_E8_R4 + MSO_E8_RFL +
MSO_E8_RE + MSO_E8_RERR+
MSO_E1_RBAD) mod 2^{24}.

3.2.2 Same Rate Received Counters Response

When the mobile station sends a *Same Rate Received Counters Response*, it shall include the following Type-specific fields in the *Service Option Control Message:*

Table 26. Type-specific Fields in the Service Option Control Message corresponding to Same Rate Received Counters Response

Field	Length (bits)
CTL_REC_TYPE (‘00000001’)	8
VECT_COUNTER_ID (‘00000001’)	8
MS0_E1_R1	24
MSO_E2_R2	24
MSO_E4_R4	24
MSO_E8_R8	24

CTL_REC_TYPE — Control record type field.

The mobile station shall set this field to ‘00000001’.

VECT_COUNTER_ID — Vector counter identification field.

The mobile station shall set this field to ‘00000001’.

MSO_E1_R1 — Counter for the number of Rate 1 frames received error free.

The mobile station shall set this field to the value of MSO_E1_R1 stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E2_R2 — Counter for the number of Rate 1/2 frames received error free.

The mobile station shall set this field to the value of MSO_E2_R2 stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E4_R4 — Counter for the number of Rate 1/4 frames received error free

The mobile station shall set this field to the value of MSO_E4_R4 stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E8_R8 — Counter for the number of Rate 1/8 frames received error free.

The mobile station shall set this field to the value of MSO_E8_R8 stored in the FTC_BUFFER, modulo 2^{24}.

3.2.3 Same Rate Transmitted Counters Response

When the mobile station sends a *Same Rate Transmitted Counters Response,* it shall include the following Type-specific fields in the *Service Option Control Message:*

Table 27. Type-specific Fields in the Service Option Control Message corresponding to Same Rate Transmitted Counters Response

Field	Length (bits)
CTL_REC_TYPE (‘00000001’)	8
VECT_COUNTER_ID (‘00000010’)	8
MSO_E1_T1	24
MSO_E2_T2	24
MSO_E4_T4	24
MSO_E8_T8	24

CTL_REC_TYPE — Control record type field.

The mobile station shall set this field to ‘00000001’.

VECT_COUNTER_ID — Vector counter identification field.

The mobile station shall set this field to ‘00000010’.

MSO_E1_T1 — Counter for the number of Rate 1 frames transmitted with no dim-and-burst or blank-and-burst, given that the generated data block was Rate 1.

The mobile station shall set this field to the value of MSO_E1_T1 stored in the RTC_BUFFER, modulo 2^{24}.

MSO_E2_T2 — Counter for the number of Rate 1/2 frames transmitted with no dim-and-burst or blank-and-burst, given that the generated data block was Rate 1/2.

The mobile station shall set this field to the value of MSO_E2_T2 stored in the RTC_BUFFER, modulo 2^{24}.

MSO_E4_T4 — Counter for the number of Rate 1/4 frames transmitted with no dim-and-burst or blank-and-burst, given that the generated data block was Rate 1/4.

The mobile station shall set this field to the value of MSO_E4_T4 stored in the RTC_BUFFER, modulo 2^{24}.

MSO_E8_T8 — Counter for the number of Rate 1/8 frames transmitted with no dim-and-burst or blank-and-burst, given that the generated data block was Rate 1/8.

The mobile station shall set this field to the value of MSO_E8_T8 stored in the RTC_BUFFER, modulo 2^{24}.

3.2.4 Transmitted Counters Response

When the mobile station sends a *Transmitted Counters Response*, it shall include the following Type-specific fields in the *Service Option Control Message:*

Table 28. Type-specific Fields in the Service Option Control Message corresponding to Transmitted Counters Response

Field	Length (bits)
CTL_REC_TYPE (‘00000001’)	8
VECT_COUNTER_ID (‘00000011’)	8
MSO_E1_T1	24
MSO_E2_T2	24
MSO_E4_T4	24
MSO_E8_T8	24
MSO_E1_TD	24
MSO_E2_TD	24
MSO_E4_TD	24
MSO_E8_TD	24
MSO_E1_TB	24
MSO_E2_TB	24
MSO_E4_TB	24
MSO_E8_TB	24

CTL_REC_TYPE — Control record type field.

The mobile station shall set this field to ‘00000001’.

VECT_COUNTER_ID — Vector counter identification field.

The mobile station shall set this field to ‘00000011’.

MSO_E1_T1 — Counter for the number of Rate 1 frames transmitted with no dim-and-burst or blank-and-burst, given that the generated data block was Rate 1.

The mobile station shall set this field to the value of MSO_E1_T1 stored in the RTC_BUFFER, modulo 2^{24}.

MSO_E2_T2 — Counter for the number of Rate 1/2 frames transmitted with no dim-and-burst or blank-and-burst, given that the generated data block was Rate 1/2.

The mobile station shall set this field to the value of MSO_E2_T2 stored in the RTC_BUFFER, modulo 2^{24}.

MSO_E4_T4 — Counter for the number of Rate 1/4 frames transmitted with no dim-and-burst or blank-and-burst, given that the generated data block was Rate 1/4.

	The mobile station shall set this field to the value of MSO_E4_T4 stored in the RTC_BUFFER, modulo 2^{24}.
MSO_E8_T8	Counter for the number of Rate 1/8 frames transmitted with no dim-and-burst or blank-and-burst, given that the generated data block was Rate 1/8.
	The mobile station shall set this field to the value of MSO_E8_T8 stored in the RTC_BUFFER, modulo 2^{24}.
MSO_E1_TD	Counter for the number of dim-and-burst frames transmitted, given that the generated data block was Rate 1.
	The mobile station shall set this field to the value of MSO_E1_TD stored in the RTC_BUFFER, modulo 2^{24}.
MSO_E2_TD	Counter for the number of dim-and-burst frames transmitted, given that the generated data block was Rate 1/2.
	The mobile station shall set this field to the value of MSO_E2_TD stored in the RTC_BUFFER, modulo 2^{24}.
MSO_E4_TD	Counter for the number of dim-and-burst frames transmitted, given that the generated data block was Rate 1/4.
	The mobile station shall set this field to the value of MSO_E4_TD stored in the RTC_BUFFER, modulo 2^{24}.
MSO_E8_TD	Counter for the number of dim-and-burst frames transmitted, given that the generated data block was Rate 1/8.
	The mobile station shall set this field to the value of MSO_E8_TD stored in the RTC_BUFFER, modulo 2^{24}.
MSO_E1_TB	Counter for the number of blank-and-burst frames transmitted, given that the generated data block was Rate 1.
	The mobile station shall set this field to the value of MSO_E1_TB stored in the RTC_BUFFER, modulo 2^{24}.
MSO_E2_TB	Counter for the number of blank-and-burst frames transmitted, given that the generated data block was Rate 1/2.
	The mobile station shall set this field to the value of MSO_E2_TB stored in the RTC_BUFFER, modulo 2^{24}.
MSO_E4_TB	Counter for the number of blank-and-burst frames transmitted, given that the generated data block was Rate 1/4.
	The mobile station shall set this field to the value of MSO_E4_TB stored in the RTC_BUFFER, modulo 2^{24}.
MSO_E8_TB	Counter for the number of blank-and-burst frames transmitted, given that the generated data block was Rate 1/8.
	The mobile station shall set this field to the value of MSO_E8_TB stored in the RTC_BUFFER, modulo 2^{24}.

3.2.5 Rate 1 Expected Counters Response

When the mobile station sends a *Rate 1 Expected Counters Response*, it shall include the following Type-specific fields in the *Service Option Control Message:*

Table 29. Type-specific Fields in the Service Option Control Message corresponding to Rate 1 Expected Counters Response

Field	Length (bits)
CTL_REC_TYPE (‘00000001’)	8
VECT_COUNTER_ID (‘00000100’)	8
MSO_E1_R1	24
MSO_E1_RD	24
MSO_E1_RB	24
MSO_E1_R2	24
MSO_E1_R4	24
MSO_E1_R8	24
MSO_E1_RFL	24
MSO_E1_RE	24
MSO_E1_RERR	24

CTL_REC_TYPE — Control record type field.

The mobile station shall set this field to ‘00000001’.

VECT_COUNTER_ID — Vector counter identification field.

The mobile station shall set this field to ‘00000100’.

MSO_E1_R1 — Counter for the number of Rate 1 frames received error free, given that the expected data block was Rate 1.

The mobile station shall set this field to the value of MSO_E1_R1 stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E1_RD — Counter for the number of dim-and-burst frames received, given that the expected data block was Rate 1.

The mobile station shall set this field to the value of MSO_E1_RD stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E1_RB — Counter for the number of blank-and-burst frames received, given that the expected data block was Rate 1.

The mobile station shall set this field to the value of MSO_E1_RB stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E1_R2 — Counter for the number of Rate 1/2 frames received with no dim-and-burst, given that the expected data block was Rate 1.

	The mobile station shall set this field to the value of MSO_E1_R2 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E1_R4	Counter for the number of Rate 1/4 frames received with no dim-and-burst, given that the expected data block was Rate 1.
	The mobile station shall set this field to the value of MSO_E1_R4 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E1_R8	Counter for the number of Rate 1/8 frames received with no dim-and-burst, given that the expected data block was Rate 1.
	The mobile station shall set this field to the value of MSO_E1_R8 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E1_RFL	Counter for the number of Rate 1 frames with bit errors received (a categorization only applicable with the Multiplex option 1[1]), given that the expected data block was Rate 1.
	The mobile station shall set this field to the value of MSO_E1_RFL stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E1_RE	Counter for the number of frames received with Insufficient frame quality (erasure), given that the expected data block was Rate 1.

[1] This counter does not get incremented when Multiplex Option 0x02 is used.

The mobile station shall set this field to the value of MSO_E1_RE stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E1_RERR	Counter for the number of Rate 1 frames received with bit errors (detected by the Markov service option), given that the expected data block was Rate 1.
	The mobile station shall set this field to the value of MSO_E1_RERR stored in the FTC_BUFFER, modulo 2^{24}.

3.2.6 Rate 1/2 Expected Counters Response

When the mobile station sends a *Rate 1/2 Expected Counters Response*, it shall include the following Type-specific fields in the *Service Option Control Message:*

Table 30. Type-specific Fields in the Service Option Control Message corresponding to Rate 1/2 Expected Counters Response

Field	Length (bits)
CTL_REC_TYPE ('00000001')	8
VECT_COUNTER_ID ('00000101')	8
MSO_E2_R1	24
MSO_E2_RD	24
MSO_E2_RB	24
MSO_E2_R2	24
MSO_E2_R4	24
MSO_E2_R8	24
MSO_E2_RFL	24
MSO_E2_RE	24
MSO_E2_RERR	24

CTL_REC_TYPE — Control record type field

The mobile station shall set this field to '00000001'.

VECT_COUNTER_ID — Vector counter identification field.

The mobile station shall set this field to '00000101'.

MSO_E2_R1 — Counter for the number of Rate 1 frames received, given that the expected data block was Rate 1/2.

The mobile station shall set this field to the value of MSO_E2_R1 stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E2_RD — Counter for the number of dim-and-burst frames received, given that the expected data block was Rate 1/2.

The mobile station shall set this field to the value of MSO_E2_RD stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E2_RB — Counter for the number of blank-and-burst frames received, given that the expected data block was Rate 1/2.

The mobile station shall set this field to the value of MSO_E2_RB stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E2_R2 — Counter for the number of Rate 1/2 frames received error free with no dim-and-burst received error free, given that the expected data block was Rate 1/2.

	The mobile station shall set this field to the value of MSO_E2_R2 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E2_R4	Counter for the number of Rate 1/4 frames received with no dim-and-burst, given that the expected data block was Rate 1/2.
	The mobile station shall set this field to the value of MSO_E2_R4 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E2_R8	Counter for the number of Rate 1/8 frames received with no dim-and-burst, given that the expected data block was Rate 1/2.
	The mobile station shall set this field to the value of MSO_E2_R8 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E2_RFL	Counter for the number of Rate 1 frames with bit errors received (a categorization only applicable with the Multiplex Option 1), given that the expected data block was Rate 1/2.
	The mobile station shall set this field to the value of MSO_E2_RFL stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E2_RE	Counter for the number of frames received with Insufficient frame quality (erasure), given that the expected data block was Rate 1/2.
	The mobile station shall set this field to the value of MSO_E2_RE stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E2_RERR	Counter for the number of Rate 1/2 frames received with bit errors (detected by the Markov service option), given that the expected data block was Rate 1/2.
	The mobile station shall set this field to the value of MSO_E2_RERR stored in the FTC_BUFFER, modulo 2^{24}.

3.2.7 Rate 1/4 Expected Counters Response

When the mobile station sends a *Rate 1/4 Expected Counters Response,* it shall include the following Type-specific fields in the *Service Option Control Message:*

Table 31. Type-specific Fields in a Service Option Control Message corresponding to Rate 1/4 Expected Counters Response

Field	Length (bits)
CTL_REC_TYPE (‘00000001’)	8
VECT_COUNTER_ID (‘00000110’)	8
MSO_E4_R1	24
MSO_E4_RD	24
MSO_E4_RB	24
MSO_E4_R2	24
MSO_E4_R4	24
MSO_E4_R8	24
MSO_E4_RFL	24
MSO_E4_RE	24
MSO_E4_RERR	24

CTL_REC_TYPE — Control record type field.

The mobile station shall set this field to ‘00000001’.

VECT_COUNTER_ID — Vector counter identification field.

The mobile station shall set this field to ‘00000110’.

MSO_E4_R1 — Counter for the number of Rate 1 frames received, given that the expected data block was Rate 1/4.

The mobile station shall set this field to the value of MSO_E4_R1 stored in the FTC_BUFFER, modulo 2^{24}

MSO_E4_RD — Counter for the number of dim-and-burst frames received, given that the expected data block was Rate 1/4.

The mobile station shall set this field to the value of MSO_E4_RD stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E4_RB — Counter for the number of blank-and-burst frames received, given that the expected data block was Rate 1/4.

The mobile station shall set this field to the value of MSO_E4_RB stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E4_R2 — Counter for the number of Rate 1/2 frames received with no dim-and-burst, given that the expected data block was Rate 1/4.

	The mobile station shall set this field to the value of MSO_E4_R2 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E4_R4	Counter for the number of Rate 1/4 frames received error free with no dim-and-burst, given that the expected data block was Rate 1/4.
	The mobile station shall set this field to the value of MSO_E4_R4 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E4_R8	Counter for the number of Rate 1/8 frames received with no dim-and-burst, given that the expected data block was Rate 1/4.
	The mobile station shall set this field to the value of MSO_E4_R8 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E4_RFL	Counter for the number of Rate 1 frames with bit errors received (a categorization only applicable with the Multiplex Option 1), given that the expected data block was Rate 1/4.
	The mobile station shall set this field to the value of MSO_E4_RFL stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E4_RE	Counter for the number of frames received with Insufficient frame quality (erasure), given that the expected data block was Rate 1/4.
	The mobile station shall set this field to the value of MSO_E4_RE stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E4_RERR	Counter for the number of Rate 1/4 frames received with bit errors (detected by the Markov service option), given that the expected data block was Rate 1/4.
	The mobile station shall set this field to the value of MSO_E4_RERR stored in the FTC_BUFFER, modulo 2^{24}.

3.2.8 Rate 1/8 Expected Counters Response

When the mobile station sends a *Rate 1/8 Expected Counters Response*, it shall include the following Type-specific fields in the *Service Option Control Message:*

Table 32. Type-specific Fields in a Service Option Control Message corresponding to Rate 1/8 Expected Counters Response

Field	Length (bits)
CTL_REC_TYPE ('00000001')	8
VECT_COUNTER_ID ('00000111')	8
MSO_E8_R1	24
MSO_E8_RD	24
MSO_E8_RB	24
MSO_E8_R2	24
MSO_E8_R4	24
MSO_E8_R8	24
MSO_E8_RFL	24
MSO_E8_RE	24
MSO_E8_RERR	24

CTL_REC_TYPE — Control record type field.

The mobile station shall set this field to '00000001'.

VECT_COUNTER_ID — Vector counter identification field.

The mobile station shall set this field to '00000111'.

MSO_E8_R1 — Counter for the number of Rate 1 frames received, given that the expected data block was Rate 1/8.

The mobile station shall set this field to the value of MSO_E8_R1 stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E8_RD — Counter for the number of dim-and-burst frames received, given that the expected data block was Rate 1/8.

The mobile station shall set this field to the value of MSO_E8_RD stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E8_RB — Counter or the number of blank-and-burst frames received, given that the expected data block was Rate 1/8.

The mobile station shall set this field to the value of MSO_E8_RB stored in the FTC_BUFFER, modulo 2^{24}.

MSO_E8_R2 — Counter for the number of Rate 1/2 frames received with no dim-and-burst, given that the expected data block was Rate 1/8.

	The mobile station shall set this field to the value of MSO_E8_R2 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E8_R4	Counter for the number of Rate 1/4 frames received with no dim-and-burst, given that the expected data block was Rate 1/8.
	The mobile station shall set this field to the value of MSO_E8_R4 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E8_R8	Counter for the number of Rate 1/8 frames received error free with no dim-and-burst, given that the expected data block was Rate 1/8.
	The mobile station shall set this field to the value of MSO_E8_R8 stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E8_RFL	Counter for the number of Rate 1 frames with bit errors received (a categorization only applicable with the Multiplex Option 1), given that the expected data block was Rate 1/8.
	The mobile station shall set this field to the value of MSO_E8_RFL stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E8_RE	Counter for the number of frames received with Insufficient frame quality (erasure), given that the expected data block was Rate 1/8.
	The mobile station shall set this field to the value of MSO_E8_RE stored in the FTC_BUFFER, modulo 2^{24}.
MSO_E8_RERR	Counter for the number of Rate 1/8 frames received with bit errors (detected by the Markov service option), given that the expected data block was Rate 1/8.
	The mobile station shall set this field to the value of MSO_E8_RERR stored in the FTC_BUFFER, modulo 2^{24}.

No text.

ANNEX A USING THE MARKOV SERVICE OPTION

This is an informative annex that outlines procedures for conducting a Markov test and a method for computing frame error rates.

A.1 Conducting a Markov Test

A Markov test may be conducted at a base station using the following procedure:

1. Start a Markov call (or clear the counters of an existing call)
2. To conduct a Markov call in Fixed Rate Mode, send a *Service Order Control Message* with TEST_MODE field set to the chosen rate and the CLEAR_COUNTERS field set to '1'
3. Wait for the test interval to elapse
4. Direct the mobile station to make a copy of the Markov counters
5. Wait for the forward synchronization and reverse synchronization frame after the action time to occur
6. Retrieve the values of the copied counters from the mobile station and compute the frame error rates

A call is started by negotiating the Markov service option (see 2.4) and initializing and connecting the service option. The service option counters are cleared at initialization, or could be cleared explicitly by the base station by sending a control order while a Markov call is in progress (see 2.7.2.2).

The duration of a test should correspond to an integral number of segments (see 2.5). The mobile station's processing of the copy counters directive enforces this test duration.

The base station sends a *Service Option Control Message* directing the mobile station to copy the received and transmitted Markov counters to buffers at the next Forward and Reverse Fundamental Channel synchronization frames. This provides a synchronized snapshot of all the Markov counters for accurate calculations of frame error rates.

The base station sends *Service Option Control Messages* to request counter values to be retrieved from the copied buffer (see 2.7.2.3). These counter values are used in frame error rate calculations.

A.2 Computation of Frame Error Rates

The frame error rates of various frames on the Forward Fundamental Channel are given by

$$FER_{Rate\ 1}\text{(Forward)} = 1 - MSO\_E1\_R1_m / MSO\_E1\_T1_b,$$

$$FER_{Rate\ 1/2}\text{(Forward)} = 1 - MSO\_E2\_R2_m / MSO\_E2\_T2_b,$$

$$FER_{Rate\ 1/4}\text{(Forward)} = 1 - MSO\_E4\_R4_m / MSO\_E4\_T4_b,$$

$$FER_{Rate\ 1/8}\text{(Forward)} = 1 - MSO\_E8\_R8_m / MSO\_E8\_T8_b,$$

assuming those base station counters exist, where counters in the mobile station are denoted by a subscript m, and counters in the base station are denoted by a subscript b.

The frame error rates of various frames on the Reverse Fundamental Channel are given by

$$FER_{Rate\ 1}\text{ (Reverse)} = 1 - \text{MSO\_E1\_R1}_b / \text{MSO\_E1\_T1}_m,$$

$$FER_{Rate\ 1/2}\text{ (Reverse)} = 1 - \text{MSO\_E2\_R2}_b / \text{MSO\_E2\_T2}_m,$$

$$FER_{Rate\ 1/4}\text{ (Reverse)} = 1 - \text{MSO\_E4\_R4}_b / \text{MSO\_E4\_T4}_m,$$

$$FER_{Rate\ 1/8}\text{ (Reverse)} = 1 - \text{MSO\_E8\_R8}_b / \text{MSO\_E8\_T8}_m,$$

assuming those base station counters exist, where counters in the mobile station are denoted by a subscript m, and counters in the base station are denoted by a subscript b.

Note that the number of dim-and-burst frames and the number of blank-and-burst frames are not used in the frame error rate calculations described above.

The values of the base station transmit counters, MSO_E1_T1_b, MSO_E2_T2_b, MSO_E4_T4_b, and MSO_E8_T8_b, can be estimated by summing the values of the corresponding mobile station counters for received frames as follows:

$$\text{MSO\_E1\_T1}_b \approx \text{MSO\_E1\_R1}_m + \text{MSO\_E1\_R2}_m + \text{MSO\_E1\_R4}_m + \text{MSO\_E1\_R8}_m + \text{MSO\_E1\_RFL}_m + \text{MSO\_E1\_RE}_m + \text{MSO\_E1\_RERR}_m$$

$$\text{MSO\_E2\_T2}_b \approx \text{MSO\_E2\_R1}_m + \text{MSO\_E2\_R2}_m + \text{MSO\_E2\_R4}_m + \text{MSO\_E2\_R8}_m + \text{MSO\_E2\_RFL}_m + \text{MSO\_E2\_RE}_m + \text{MSO\_E2\_RERR}_m$$

$$\text{MSO\_E4\_T4}_b \approx \text{MSO\_E4\_R1}_m + \text{MSO\_E4\_R2}_m + \text{MSO\_E4\_R4}_m + \text{MSO\_E4\_R8}_m + \text{MSO\_E4\_RFL}_m + \text{MSO\_E4\_RE}_m + \text{MSO\_E4\_RERR}_m$$

$$\text{MSO\_E8\_T8}_b \approx \text{MSO\_E8\_R1}_m + \text{MSO\_E8\_R2}_m + \text{MSO\_E8\_R4}_m + \text{MSO\_E8\_R8}_m + \text{MSO\_E8\_RFL}_m + \text{MSO\_E8\_RE}_m + \text{MSO\_E8\_RERR}_m$$

The values of the mobile station transmit counters MSO_E1_T1_m, MSO_E2_T2_m, MSO_E4_T4_m, and MSO_E8_T8_m, can be estimated at the mobile station by summing the values of the corresponding base station counters for received frames as follows:

$$\text{MSO\_E1\_T1}_m \approx \text{MSO\_E1\_R1}_b + \text{MSO\_E1\_R2}_b + \text{MSO\_E1\_R4}_b + \text{MSO\_E1\_R8}_b + \text{MSO\_E1\_RFL}_b + \text{MSO\_E1\_RE}_b + \text{MSO\_E1\_RERR}_b$$

$$\text{MSO\_E2\_T2}_m \approx \text{MSO\_E2\_R1}_b + \text{MSO\_E2\_R2}_b + \text{MSO\_E2\_R4}_b + \text{MSO\_E2\_R8}_b + \text{MSO\_E2\_RFL}_b + \text{MSO\_E2\_RE}_b + \text{MSO\_E2\_RERR}_b$$

$$\text{MSO\_E4\_T4}_m \approx \text{MSO\_E4\_R1}_b + \text{MSO\_E4\_R2}_b + \text{MSO\_E4\_R4}_b + \text{MSO\_E4\_R8}_b + \text{MSO\_E4\_RFL}_b + \text{MSO\_E4\_RE}_b + \text{MSO\_E4\_RERR}_b$$

$$\text{MSO\_E8\_T8}_m \approx \text{MSO\_E8\_R1}_b + \text{MSO\_E8\_R2}_b + \text{MSO\_E8\_R4}_b + \text{MSO\_E8\_R8}_b + \text{MSO\_E8\_RFL}_b + \text{MSO\_E8\_RE}_b + \text{MSO\_E8\_RERR}_b$$

ANNEX B MARKOV CALL FLOW EXAMPLES (for a system operating in MC-41 mode)

This is an informative annex containing examples of Markov call flows using Service Negotiation. The diagrams follow this convention:

- All messages are received without error
- Acknowledgments are not shown.

Mobile Station				**Base Station**
Detects user-initiated call				
Sends *Origination Message* specifying the Markov service option	>	Access Channel	>	Sets up Traffic Channel Begins sending null Traffic Channel data
Sets up Traffic Channel	<	Paging Channel	<	Sends *Channel Assignment* message (Granted Mode = Streamlined)
Receives N_{5m} consecutive valid frames				
Begins sending the Traffic Channel preamble	>	Reverse Traffic Channel	>	Acquires the Reverse Traffic Channel
Begin transmitting null Traffic Channel data	<	Forward Traffic Channel	<	Sends *Base Station Acknowledgment Order*
	<	Forward Traffic Channel	<	Sends *Service Connect Message*
Sends *Service Connect Completion Message*	>	Reverse Traffic Channel	>	
Enters the *Conversation Substate*, and connects the Markov service option at the action time specified in the *Service Connect Message*. Generates Rate 1/8 data blocks from the time of service option connection to the frame prior to the first synchronization frame. At the first synchronization frame initializes the Markov service option.				Connects and initializes the Markov service option following the action time specified in the *Service Connect Message*.

Figure B-1. Simple Markov Call Flow, Mobile Station Origination

Mobile Station				**Base Station**
	<	Paging Channel	<	Sends *General Page Message* with Service Option Number = 54
Sends *Page Response Message* returning Markov service option number	>	Access Channel	>	Sets up Traffic Channel Begins sending null Traffic Channel data
Sets up Traffic Channel	<	Paging Channel	<	Sends *Channel Assignment Message* with GRANTED MODE = StreamLined
Receives N_{5m} consecutive valid frames				
Begins sending the Traffic Channel preamble	>	Reverse Traffic Channel	>	Acquires the reverse Traffic Channel
Begins transmitting null Traffic Channel data	<	Forward Traffic Channel	<	Sends Base Station Acknowledgment Order
	<	Forward Traffic Channel	<	Sends *Service Connect Message*
Transitions to *Waiting for Mobile Station Answer Substate* and initiates an "auto-answer"	<	Forward Traffic Channel	<	Sends *Alert With Information Message*
Sends *Connect Order*, enters the *Conversation Substate,*	>	Reverse Traffic Channel	>	
Sends *Service Connect Completion Message*	>	Reverse Traffic Channel	>	
Connects the Markov service option at the action time specified in the *Service Connect Message*. Generates Rate 1/8 data blocks from the time of service option connection to the frame prior to the first synchronization frame. At the first synchronization initializes the Markov service option.				Initializes and connects the Markov service option following the action time specified in the *Service Connect Message*.

Figure B-2. Simple Markov Call Flow, Mobile Station Termination

Mobile Station		Base Station
(Markov Call Active)		*(Markov Call Active)*
	< Forward Traffic Channel <	Sends Markov *Service Option Control Message* specifying a new rate
Sends an acknowledgment		
Accepts the new rate.		
Starts processing primary traffic at the new rate specified in the *Service Option Control Message* from the next synchronization frame.		Starts processing primary traffic at the new rate from the next synchronization frame.

Figure B-3. Markov Call Flow, Base Station Commanded Test Mode Change

No text.

ANNEX C MSO OPERATION EXAMPLES

C.1 Markov that uses Multiplex Option 0x01

Assume that in the variable rate mode, MSO is about to transmit frame number 0xab89efad on the Forward Fundamental Channel to a mobile station with E equal to 0x9F000307 (see 2.5 for detail on how E is set). Since the least significant nine bits of (0xab89efad xor 0x2aaaaaaa) equal 0x107, and the least significant nine bits of the E are 0x0107, it is time to resynchronize the Forward Fundamental Channel Markov process. The Markov state is set to 15 and the associated pseudo-random number generator is initialized with FRNG set equal to the 31 least-significant bits of (0xab89efad xor 0x2aaaaaaa) = 0x01234507 as follows (see 2.9.1.1):

01234507	(FRNG: starting value for the Synchronization Frame)
3288cf26	(FRNG: 1st iteration)
33d7e1b5	(FRNG: 2nd iteration)
22234caa	(FRNG: 3rd iteration)
3b7e3e68	(FRNG: 4th iteration)

From state 15, the valid next states are 12, 13, 14, and 15 (see 2.9.2.1.2.2). The probabilities of transitions to each of these states are given in Table 14. After reinitialization, the Forward Fundamental Channel Markov service option would compute $y_n(1)$ = FRNG/128 = 0x3b7e3e68/128 = 0x76fc7c. The least significant 15 bits of $y_n(1)$, z_n, is equal to 0x7c7c, or 31868. In state 15, z_n in the range (29753,32472) dictates the next state s(n) to be $(4\times 15+2) \bmod 16 = 14$.

Since frame rate = $2^{-(s(n) \bmod 4)} = 2^{-(14 \bmod 4)} = 2^{-2}$, the Markov service option will generate a Rate 1/4 data block. A Rate 1/4 data block uses 40 bits, starting with the same 24-bit number that was used to determine the new state.

FRNG = 0x3b7e3e68, $y_n(1)$ = 0x76fc7c

FRNG = 0x5d333c5b, $y_n(2)$ = 0xba6678

Each 24-bit number $y_n(k)$ is written to the frame buffer in “little-endian” fashion. So 0x76fc7c turns into the byte stream 0x7c 0xfc 0x76. The “little-endian” version of the next 24-bit number, 0xba6678, is written immediately after the first number. Since the final 8 bits are not needed, they are masked out and the buffer looks like:

7c fc 76 78 66.

The Markov service option supplies the buffer specified above as a data block to the multiplex sublayer, assuming that the multiplex sublayer requests for a data block of the same size (i.e., no signaling or secondary traffic carried in this frame).

For the next Markov frame, the pseudo-random numbers $y_n(k)$ are:

FRNG	$y_n(k)$
4ebfaa2a	9d7f54

093cd3ca	1279a7
78747782	f0e8ef
26523596	4ca46b
5f3c1e81	be783d
63f6d7ff	c7edaf
62ded99e	c5bdb3

The 15 least-significant bits of $y_n(1)$, z_n, is 0x7f54 = 32596. z_n is used to look up the new state: $(4\times 14 + 0) \bmod 16 = 8$. The Markov service option will generate a Rate 1 data block using seven 24-bit numbers, $y_n^{LE}(1)$ through $y_n^{LE}(7)$ followed by three zero bits (see 2.9.3.1). The complete data block looks like this:

54 7f 9d a7 79 12 ef e8 f0 6b a4 4c 3d 78 be af ed c7 b3 bd c5 ‘000’

The next FRNG, 0x29428d, selects state 0 which generates another Rate 1 data block. Nine of the next 12 data blocks are Rate 1. One might say that the Forward Fundamental Channel is simulating a talker.

A while later, frame number 0xab89f052 is about to be generated for the Reverse Fundamental Channel. Since the least-significant nine bits of (0xab89f052 xor 0x55555555) equal 0x107, and the least-significant nine bits of the E are 0x0107, it is time to resynchronize the Reverse Fundamental Channel Markov process. The Markov state is set to 15 and the associated pseudo-random number generator is initialized with RRNG set equal to the 31 least-significant bits of (0xab89f052 xor 0x55555555) = 0x7edca507 as follows (see 2.9.1.1):

7edca507	(RRNG starting value for the Synchronization Frame)
47d6afa2	(RRNG: 1st iteration)
5fa4d986	(RRNG: 2nd iteration)
3fc51d78	(RRNG: 3rd iteration)
2611d1fd	(RRNG: 4th iteration)

The Reverse Fundamental Channel Markov service option first computes $y_n(1)$ = RRNG/128 = 0x2611d1fd/128 = 0x4c23a3. The 15 least-significant bits of $y_n(1)$, z_n is equal to 0x23a3 or 9123. z_n dictates transition from state 15 to state $(4\times 15+3) \bmod 16 = 15$ and a data block of Rate 1/8 with information bits represented in hexadecimal form as follows:

a3 23

For the next six frames, the Reverse Fundamental Channel Markov process will generate only Rate 1/8 data blocks in state 15. One might say that the Reverse Fundamental Channel is simulating a listener.

Table C.1-1 contains several Forward Fundamental Channel Markov data blocks in a variable rate test for E equal to 0x9f000307 and a start frame number equal to 0xab89efad (06/13/1995 05:13:24.100).

Table C.1-1. Forward Fundamental Channel Markov Data Blocks (Part 1 of 2)

Frame Number	Frame Rate	Forward Fundamental Channel Markov Data Blocks Contents in Hex and Binary
ab89efad	1/4	7C FC 76 78 66
ab89efae	1	54 7F 9D A7 79 12 EF E8 F0 6B A4 4C 3D 78 BE AF ED C7 B3 BD C5 ‘000’
ab89efaf	1	8D 42 29 FE 5B D0 44 87 47 DE A3 01 7D 4A AD 34 89 F5 FD F3 02 ‘000’
…		
ab89efb6	1	33 77 80 CF C0 11 0D 7D 89 AE F1 70 2D FC 0A A9 F9 31 66 DC FD ‘000’
ab89efb7	1	BF DC 90 47 A3 8C A0 9F 33 82 EA 34 D1 34 10 74 9C FB 33 85 DC ‘000’
ab89efb8	1/2	CB 02 AD 6B 8B 92 00 56 FF 9E
ab89efb9	1/4	BD 35 2C 5D 46
ab89efba	1/8	97 B2
ab89efbb	1/2	3E F6 B5 D1 9C 39 91 9D 66 57
ab89efbc	1	3E 40 38 B7 C0 01 07 48 13 53 CC DD B1 61 91 94 B8 A4 AC 08 52 ‘000’
ab89efbd	1	AE 74 B7 50 5D 4D 17 4D 29 2A 38 84 22 88 83 58 94 5E 66 51 5D ‘000’
…		
ab89f1ab	1/8	4D D3
ab89f1ac	1/8	88 89
ab89f1ad	1/8	C8 13 resync
ab89f1ae	1/8	E8 F0
…		
ab89f394	1/8	38 66
ab89f395	1/4	71 F4 6F 7B 3C

Table C.1-1. Forward Fundamental Channel Markov Data Blocks (Part 2 of 2)

Frame Number	Frame Rate	Forward Fundamental Channel Markov Data Block Contents in Hex and Binary
ab89f396	1/8	A6 BD
ab89f397	1	7B FC F9 A5 27 2F F0 DD D3 89 F5 8F 88 04 41 F5 A8 90 04 91 44 ‘000’
ab89f398	1	1C C0 8C 80 94 98 04 90 3D B7 31 BA C2 0D 16 09 4D E1 EB B5 88 ‘000’
ab89f399	1	52 75 5F 7C 8E 0F 22 9F 53 DD 99 F4 3B BB A1 D8 47 0B 78 CB 99 ‘000’
ab89f39a	1	8B 59 FD E1 D0 01 F0 7D 38 73 36 D4 DB C8 42 FA C8 90 0C B0 7A ‘000’
ab89f39b	1	BD EA BB A0 58 30 D0 A5 0A 82 1A 0C E8 63 A0 AC 50 FF 36 88 09 ‘000’
ab89f39c	1	BC A4 CD 50 51 FA EC 78 F0 AC FF 92 F7 9B CF 71 85 08 C4 FA 70 ‘000’
ab89f39d	1/2	1E 83 5F CA 3B 99 5E 6A 24 30
ab89f39e	1/4	53 B7 00 C4 D6
ab89f39f	1/8	50 17
…		
ab89f3ac	1/8	B2 89
ab89f3ad	1/8	1F E3 resync
ab89f3ae	1/8	DE 12
ab89f3af	1/8	9D AE
ab89f3b0	1/8	69 CB
ab89f3b1	1/4	BA 78 BA FE 06
ab89f3b2	1/8	6A 24

Table C.1-2 contains several Reverse Fundamental Channel Markov data blocks in a variable rate test for E equal to 0x9f000307 and a start frame number equal to 0xab89f052 (06/13/1995 05:13:27.400).

Table C.1-2. Reverse Fundamental Channel Markov Data Blocks (Part 1 of 3)

Frame number	Frame Rate	Reverse Fundamental Channel Markov Data Block Contents in Hex and Binary
ab89f052	1/8	A3 23 resync
ab89f053	1/8	99 E2
...		
ab89f058	1/8	DE 02
ab89f059	1/4	00 7E 16 AB 72
ab89f05a	1	6A 75 4E EC 9A FE E2 34 6D 50 E8 AA 21 1C 7A 7E D7 CC BD BE 57 '000'
ab89f05b	1	EA A3 AB 32 60 96 6A AE 85 30 D0 7D F5 36 EF 83 2B 01 35 C3 CF '000'
ab89f05c	1	6D DE 18 AD 02 B3 60 DA 74 3F E4 AC 0F E9 BC 59 F3 68 D5 5A 40 '000'
ab89f05d	1	28 6D 0B 4D 8C 2B CA 4D 08 68 0D 2B EE 26 7D A3 D8 86 FD C4 F8 '000'
ab89f05e	1	08 D2 4C A8 16 71 7C 76 86 3F 06 CD 3B 2F 55 05 D9 8F E9 E5 F0 '000'
ab89f05f	1	7B 38 86 3A 30 E6 48 6B 68 D8 4A 5B F0 CC 8E E2 DD 30 5A 41 37 '000'
...		
ab89f251	1/8	64 0C
ab89f252	1/8	4D 54 resync
ab89f253	1/8	A3 C0
...		
ab89f44d	1/8	8A 96
ab89f44e	1/8	79 6B
ab89f44f	1/2	01 FF 79 D9 AC 54 1D EA 1F 6C
ab89f450	1	98 57 F2 8A CC 54 EB A8 40 27 F9 11 5A 7E FC 4B 4A CB E0 97 7A '000'
ab89f451	1	79 F7 88 B9 3D 2F 80 59 7D BA F5 7E 85 AB 36 76 AC 36 5E 82 74 '000'
ab89f452	1/8	50 C2 resync

1 **Table C.1-2. Reverse Fundamental Channel Markov Traffic Data Blocks (Part 2 of 3)**

Frame number	Frame Rate	Reverse Fundamental Channel Markov Data Block Contents in Hex and Binary
ab89f453	1/8	84 26
…		
ab89f485	1	2B A6 3C 5C 80 C1 1F 21 D2 57 96 7C E0 38 72 91 2A F4 70 A4 16 ‘000’
ab89f486	1	5F E7 85 03 2D 19 18 5F DA 39 3A 99 86 B1 BD 30 0C D2 8E 30 1E ‘000’
ab89f487	1	C6 D1 05 FF 2A 0F DF F2 CF 46 1E 52 25 BA 41 17 E0 23 9E 1B 4D ‘000’
ab89f488	1	0C 2F 50 C2 C7 40 0C B4 FA E0 A9 42 B2 C2 9E 56 58 00 DA A7 A7 ‘000’
ab89f489	1/2	3F 09 FD A2 1C 6A D8 E1 7D CC
ab89f48a	1/4	53 84 BF F7 76
ab89f48b	1	DE 78 3A 54 6E D5 B2 87 3E 93 C4 3E 28 D0 DB 7E 2C 3F 9B 0F 82 ‘000’
ab89f48c	1/2	0A 90 CE 88 AC 52 47 4C BD B2
ab89f48d	1/4	28 11 11 B1 5B
ab89f48e	1/8	AA D3
ab89f48f	1	04 7D 6A F3 96 35 39 57 49 76 78 FD E0 AE EF 24 F6 C1 44 ED 06 ‘000’
ab89f490	1	04 25 C3 4A 5D B3 0C CA B1 37 03 48 F3 34 CB DC 76 01 98 68 22 ‘000’
ab89f491	1	2E F9 00 D5 47 E7 97 F8 1C 08 BC 04 35 D8 D4 F4 A5 BE 3A 65 81 ‘000’
ab89f492	1	6F E4 1C C0 3E D9 89 D1 A6 95 9C 06 AD 0C 12 7C 49 FE D6 7D 8A ‘000’
ab89f493	1	2B A0 4B 07 88 00 8B 96 E2 85 A3 09 AE 80 CE 0D 39 62 12 BC 8F ‘000’
ab89f494	1	7E 54 84 98 49 C7 2D C7 B0 E5 8A E4 7E EE 5A 6E A8 DF 6B FE AA ‘000’
ab89f495	1	39 3A 25 71 8F 11 A6 53 E0 F9 D4 93 6D 43 83 51 BB BF D9 03 A3 ‘000’

Table C.1-2. Reverse Fundamental Channel Markov Traffic Data Blocks (Part 3 of 3)

Frame number	Frame Rate	Reverse Fundamental Channel Markov Data Block Contents in Hex and Binary
ab89f496	1	95 CB 51 6C E1 0C 55 AF A3 C2 1C 4C E3 0B F4 0F 78 38 23 52 52 ‘000’
ab89f497	1/2	D8 85 8E 6D 45 F5 DB 15 A1 F6
ab89f498	1/4	17 13 C6 DE 71
ab89f499	1/8	16 C3

C.2 Markov that uses Multiplex Option 0x02

Assume that in the variable rate mode, MSO is about to transmit frame number 0xec918e03 on the Forward Fundamental Channel to a mobile station with E equal to 0x9F0302A9. Since the least-significant nine bits of (0xec918e03 xor 0x2aaaaaaa) equal 0x0a9, and the least-significant nine bits of the E are 0x0a9, it is time to resynchronize the Forward Fundamental Channel Markov process. The forward Markov state is set to 15 and the associated pseudo-random number generator is initialized with FRNG set equal to the 31 least-significant bits of (0xec918e03 xor 0x2aaaaaaa) = 0x463b24a9 as follows (see 2.9.1.1):

463b24a9 (FRNG: Starting value for the Synchronization Frame)

54e3f744 (FRNG: 1st iteration)

427ebce6 (FRNG: 2nd iteration)

0ea3c225 (FRNG: 3rd iteration)

211f12a5 (FRNG: 4th iteration)

From state 15, the valid next states are 12, 13, 14, and 15 (see 2.9.2.1.2). The probabilities of transitions to each of these states are given in Table 14. After reinitialization, the Forward Fundamental Channel Markov service option would compute $y_n(1)$ = FRNG/128 = 0x211f12a5/128 = 0x423e25. The least-significant 15 bits of $y_n(1)$, z_n, is equal to 0x3e25 or 15,909. In state 15, z_n less than 29,753 dictates the next state s(n) to be $(4\times 15+3) \bmod 16 = 15$ again.

Since frame rate = $2^{-(s(n) \bmod 4)} = 2^{-(15 \bmod 4)} = 2^{-3}$, the Markov service option will generate a Rate 1/8 data block. A Rate 1/8 data block uses 20 bits, starting with the same 24-bit number $y_n(1)$ that was used to determine the new state as follows:

FRNG=0x211f12a5, $y_n(1)$=0x423e25

The 24-bit number $y_n(1)$ is written to the data block buffer in "little-endian" fashion. So 0x423e25 turns into the byte stream 0x25 0x3e 0x42. Since the final 4 bits are not needed, they are masked out and the buffer looks like this:

25 3e ‘0100’

The Markov service option supplies the buffer specified above as a data block to the multiplex sublayer, assuming that the multiplex sublayer requests for a data block of the same size (i.e., no signaling or secondary traffic carried in this frame).

For the next Markov frame, FRNG and $y_n(1)$ are as follows:

FRNG=7f011f9f, $y_n(1)$= fe023f

and this generates another Rate 1/8 data block with the following content:

3f 02 ‘1111’

Later, at frame number 0xec918e43, FRNG = 0x44ff7633, and $y_n(1)$ = 0x89fef6. The 15 least-significant bits of $y_n(1)$, z_n, is equal to 0x7ef6 or 32,502. z_n is used to look up the new state: $(4\times 15+1 \bmod 16) = 13$. The Markov service option will generate a Rate 1/2 data block using six 24-bit numbers, $y_n^{LE}(1)$ through $y_n^{LE}(6)$. The complete 124-bit data block looks like this:

f6 fe 89 e9 e2 c1 e6 43 18 a2 da 11 ec c9 28 ‘0001’

For the next frame z_n = 0x1e85 = 7813. This causes the forward Markov process to transition from state 13 to state 4, generating a 266-bit, Rate 1 data block using eleven 24-bit numbers, $y_n^{LE}(1)$ through $y_n^{LE}(11)$ and two zero bits (see 2.9.3.2). The complete data block looks like this:

85 9e f9 6b 48 16 49 8e ec b1 86 71 91 dd 41 d3 5e 39 1e 7d 80 67 7b 96 1b ac 7f
64 5d fc f3 6c 57 ‘00’

A while later, frame number 0xec9191fc is about to be generated for the Reverse Fundamental Channel. Since the least-significant nine bits of (0xec9191fc xor 0x55555555) equal 0x0a9, and the least significant nine bits of the E are 0x0a9, it is time to resynchronize the Reverse Fundamental Channel Markov process. The Reverse Fundamental Channel Markov state is set to 15 and the associated pseudo-random number generator is initialized with RRNG set equal to the 31 least-significant bits of (0xec9191fc xor 0x55555555) = 0x39c4c4a9 as follows (see 2.9.1.1):

39c4c4a9	(RRNG: Starting value for the Synchronization Frame)
254b50e0	(RRNG: 1st iteration)
73aab540	(RRNG: 2nd iteration)
4c61b813	(RRNG: 3rd iteration)
237c0e92	(RRNG: 4th iteration)

The Reverse Fundamental Channel Markov process computes $y_n(1)$ = RRNG/128 = 0x237c0e92/128 = 0x46f81d. The 15 least-significant bits of $y_n(1)$, z_n, dictates transition from state 15 to state $(4\times 15+2) \bmod 16 = 14$ and generation of a 54-bit, Rate 1/4 data block with information bits as follows:

1d f8 46 4a 41 4b ‘011000’

For the next seven frames, for the Reverse Fundamental Channel Markov process will generate only Rate 1/8 data blocks.

Table C.2-1 contains several Forward Fundamental Channel Markov data blocks in a variable rate test for E equal to 0x9f0302a9 and a start frame number equal to 0xec918e03 (02/20/1996 18:26:10.620).

Table C.2-1. Forward Fundamental Channel Markov Traffic Data Blocks (Part 1 of 2)

Frame Number	Frame Rate	Forward Fundamental Channel Markov Data Block Contents in Hex and Binary
ec918e03	1/8	25 3E '0100'
ec918e04	1/8	3F 02 '1111'
...		
ec918fe2	1	B3 13 5E E8 5E 5F 8B 0D 50 C3 45 A9 AF 46 23 15 AD F5 03 4B 36 19 DB 76 E8 54 2A BD 6B 2C E1 80 55 '00'
ec918fe3	1	27 3C 80 66 54 ED AE FB 3F C5 89 A4 DF 0D 51 E6 DD 65 74 43 CB 14 75 B9 D4 84 B5 97 B3 23 19 BB E3 '00'
ec918fe4	1	B0 77 10 43 FC 21 DC D1 38 20 FE 59 DB 06 3B 0F 17 3F 94 E0 02 94 29 E6 18 F3 B3 61 CF 1C 02 18 73 '00'
ec918fe5	1	5C 4C 2D FB 4E F0 48 7F D1 15 58 FB 3A CC 53 5E 16 85 3B 8F 7F 0E 8B 94 F3 6C 35 8D D6 83 FE E0 7A '00'
ec918fe6	1	EB 56 49 F0 71 E9 57 50 37 F1 82 7B 48 A9 D1 7A F5 C0 7C 1D 34 F2 C9 7B C2 48 07 45 E8 39 BE 0E C0 '00'
ec918fe7	1	0D F9 07 F0 E9 6F 54 A1 67 D3 9E 90 33 61 AB AA 5D 7A D6 4B 9B 74 E4 8F 32 99 DF D6 AC C2 1E 1B E1 '00'
ec918fe8	1/2	7E 89 BB E1 BB 3F BB D1 47 71 58 1A 83 6C A4 '0100'
ec918fe9	1/4	94 0F F7 AF C3 1F '110101'
ec918fea	1/8	83 1B '1011'
ec918feb	1/8	D6 5D '0110'
...		
ec919001	1/8	12 C8 '0110'
ec919002	1/8	D9 4D '1110'
ec919003	1/8	71 55 '0110' resync

Table C.2-1. Forward Fundamental Channel Markov Traffic Data Blocks (Part 2 of 2)

Frame Number	Frame Rate	Forward Fundamental Channel Markov Data Block Contents in Hex and Binary
ec919004	1/8	AE 8C '1000'
...		
ec919051	1/8	EA EB '1010'
ec919052	1/4	A3 7D 66 D4 8B C2 '101111'
ec919053	1	81 F3 AB 24 B4 FF B1 C3 8B 3D C1 DC 77 95 12 57 E6 12 B7 6A D0 85 45 0E 2F 56 F6 83 36 94 33 0C 87 '00'
ec919054	1	C5 F1 31 D9 ED F7 79 7A 20 9F CA 48 A3 97 EE 82 7E 25 8D B7 94 DA C8 9E C3 7D 94 55 C2 CC 40 7E EA '00'
ec919055	1	C8 9E 06 CC 90 A2 2D 60 D0 DB 55 5A D1 BB BA B8 BE 80 AE 45 69 4F A6 5D ED 94 51 44 8F 08 AF C5 F5 '00'
ec919056	1	4D 92 85 C8 08 48 76 90 38 5F 3E 94 F1 FD 8A 3E 0B 26 EA 4A AC 2D 64 6A 6B E8 D6 57 F5 34 11 3F D7 '00'
ec919057	1	88 B1 6D 04 5B A2 93 69 05 F0 5A 56 7B 4C 6C 95 24 11 36 D9 78 87 A6 FC F7 20 19 7E 58 C3 B7 BD E6 '00'
ec919058	1	3A 49 B1 FD 9E 3E 06 2A 38 35 F7 4E 59 BD 47 1A 2E E0 CC BC F2 42 FD 48 D1 FC EA 18 09 7C C7 15 39 '00'
...		
ec919201	1/8	F4 37 '0011'
ec919202	1/8	88 92 '0101'
ec919203	1/8	C7 24 '1000' resync
ec919204	1/8	A4 AE '1100'
ec919205	1/8	CA B5 '0101'

Table C.2-2 contains several Reverse Fundamental Channel Markov data blocks in a variable rate test for E equal to 0x9f0302a9 and a start frame number equal to 0xec9191fc (02/20/1996 18:26:30.960).

Table C.2-2. Reverse Fundamental Channel Markov Traffic Data Blocks (Part 1 of 2)

Frame number	Frame Rate	Reverse Fundamental Channel Markov Data Block Contents in Hex and Binary
ec9191fc	1/4	1D F8 46 4A 41 4B '011000' resync
ec9191fd	1/8	CF 40 '0110'
ec9191fe	1/8	46 13 '0010'
...		
ec9193b1	1	2F D0 B3 6E CE 28 F4 D7 08 37 D5 99 6B 17 7D 2F 8B 8C 95 C0 05 EF 92 A6 C1 89 F8 9D 0E 1C 2A 6D 03 '00'
ec9193b2	1	7E 1F F4 8F 98 3F 7D D7 38 E4 6C CB FE 0E 5A 1C 63 8E F7 E7 0C C0 34 51 43 4B 5E A5 4D 9F F7 C7 A2 '00'
ec9193b3	1	89 40 F6 AF EF 06 B2 06 62 A7 B1 A5 67 50 32 58 9C 3C 11 57 3C 35 1D 78 E0 C0 C5 4B D1 F9 96 C1 1B '00'
ec9193b4	1/2	52 83 42 8E B5 BB 0B BB 8C 55 F2 4B 95 E5 12 '0110'
ec9193b5	1	13 EE 12 1A 3C CC 46 F3 7D 0B 7E EE B6 2E 95 07 C3 2D D1 1A 5F 0B 90 D9 BD C7 7F 18 73 12 0D 3B 42 '00'
ec9193b6	1	C0 13 33 F3 CD 55 D8 12 44 A3 4E 31 C5 E4 21 B1 81 32 57 AA E0 00 42 CF CD 1D F6 F2 9A 1E 6B 99 4E '00'
ec9193b7	1	E8 51 3A 92 96 D7 D0 8C DE 92 BD EE 8B DD DF 2F 0F 4A F1 03 2B 9E F7 0F 55 AF 49 B4 21 96 DC F1 7E '00'
...		
ec9193fb	1/8	9F 22 '0011'
ec9193fc	1/8	C6 28 '0001' resync
ec9193fd	1/8	55 1F '0001'
ec9193fe	1/8	82 06 '1100'
ec9193ff	1/4	30 7C 7C 41 3B BD '111101'
...		
ec9195fb	1/8	3E 9B '0110'
ec9195fc	1/8	C9 96 '1001' resync
ec9195fd	1/8	36 85 '1011'

Table C.2-2. Reverse Fundamental Channel Markov Traffic Data Blocks (Part 2 of 2)

Frame number	Frame Rate	Reverse Fundamental Channel Markov Data Block Contents in Hex and Binary
...		
ec919671	1	1D C4 5D 5E 6A F6 EA 45 C1 E4 3B D5 DA FD 4E EB 30 FC 6C 99 EF 93 87 41 ED D3 2B 48 70 66 2E AF 55 '00'
ec919672	1/2	2E 09 60 91 E1 FA FF 1A EF D3 5B D5 9E A3 7F '1000'
ec919673	1/4	44 0C 37 B4 61 06 '111011'
ec919674	1	CD 78 BE FE 11 ED 25 4E 38 2E 98 92 F3 21 45 A9 EC B7 AB 61 12 4F 3E CA BD D4 C0 32 ED CE A1 AD 36 '00'
...		
ec919683	1	69 0C 54 97 D2 FA 43 C2 17 7B ED D2 DE 2E E5 DE F4 67 A6 47 FD A6 19 6B 7C 1C 61 AF 50 95 ED 37 E4 '00'
ec919684	1	45 C5 13 64 6A FC 98 01 AD 40 C0 43 8E C4 02 9E 6D B6 E0 C5 D6 62 2A 59 7F AB ED 90 50 96 FB 27 83 '00'
ec919685	1/2	F5 09 B6 D6 E1 47 8B C8 3B 8C 4F EB A5 7E B3 '0000'
ec919686	1/4	74 09 15 69 BA 1F '011101'
ec919687	1/4	86 55 F8 33 04 B7 '100001'
ec919688	1/8	1E AA '0000'

ANNEX D Bibliography

This is an informative annex. The documents listed in this annex are for information only and are not essential for the completion of the requirements of this specification.

—Books & Journals

1. Park and Miller, "Random Number Generators: Good Ones Are Hard To Find," in *Communications of the ACM*, Volume 31, Number 10, October 1988.

2. Press, Tevkolsky, Vetterling, and Flannery, *Numerical Recipes in C*, Second Edition, Cambridge University Press, 1988.