WIRELESS PERSONAL COMMUNICATIONS SYSTEMS

NORTH AMERICAN TDMA INTERIM STANDARD 136

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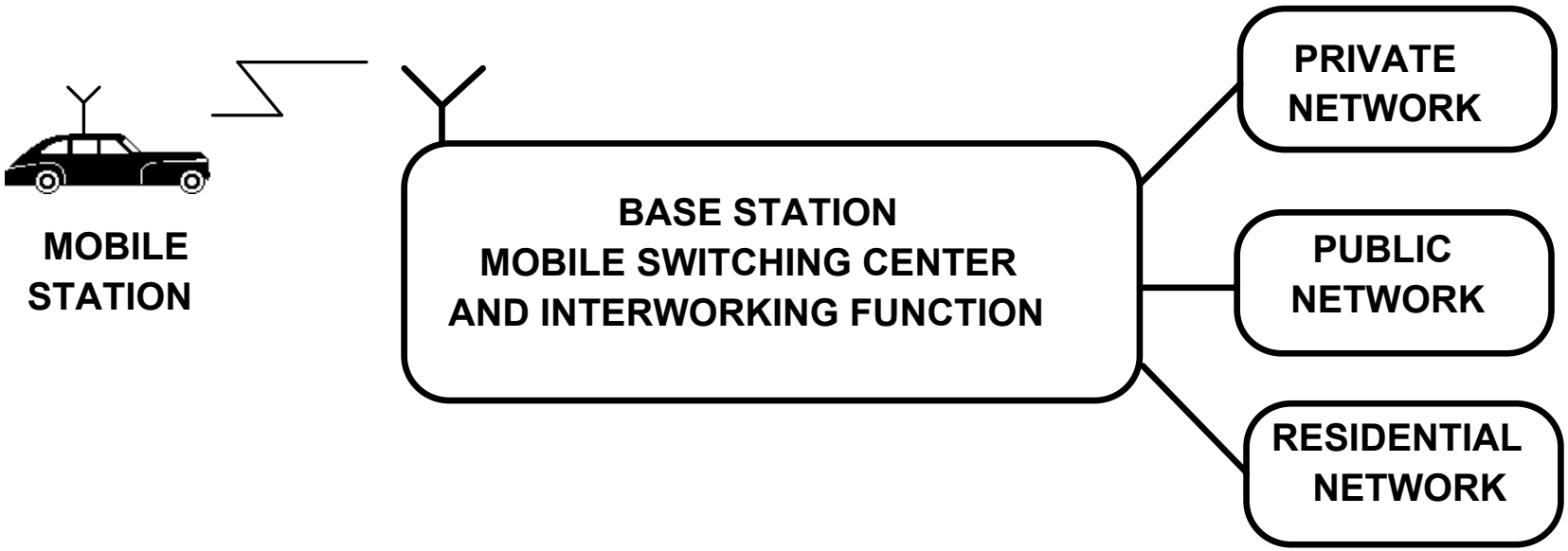
Overview

- Dual mode operation
- Digital traffic channels DTCH (IS-54)
  - **Cellular efficiency**
- AMPS control channels
- Digital control channels
  - **Cellular efficiency**
  - Power conservation
  - Expanded services

Overview

- Combat channel impairments
  - Block codes
  - Convolutional codes
  - Interleaving
  - Adaptive equalization
  - Diversity reception
- Speech compression
- Authentication and privacy
- Mobile assisted handoff
- Sleep mode

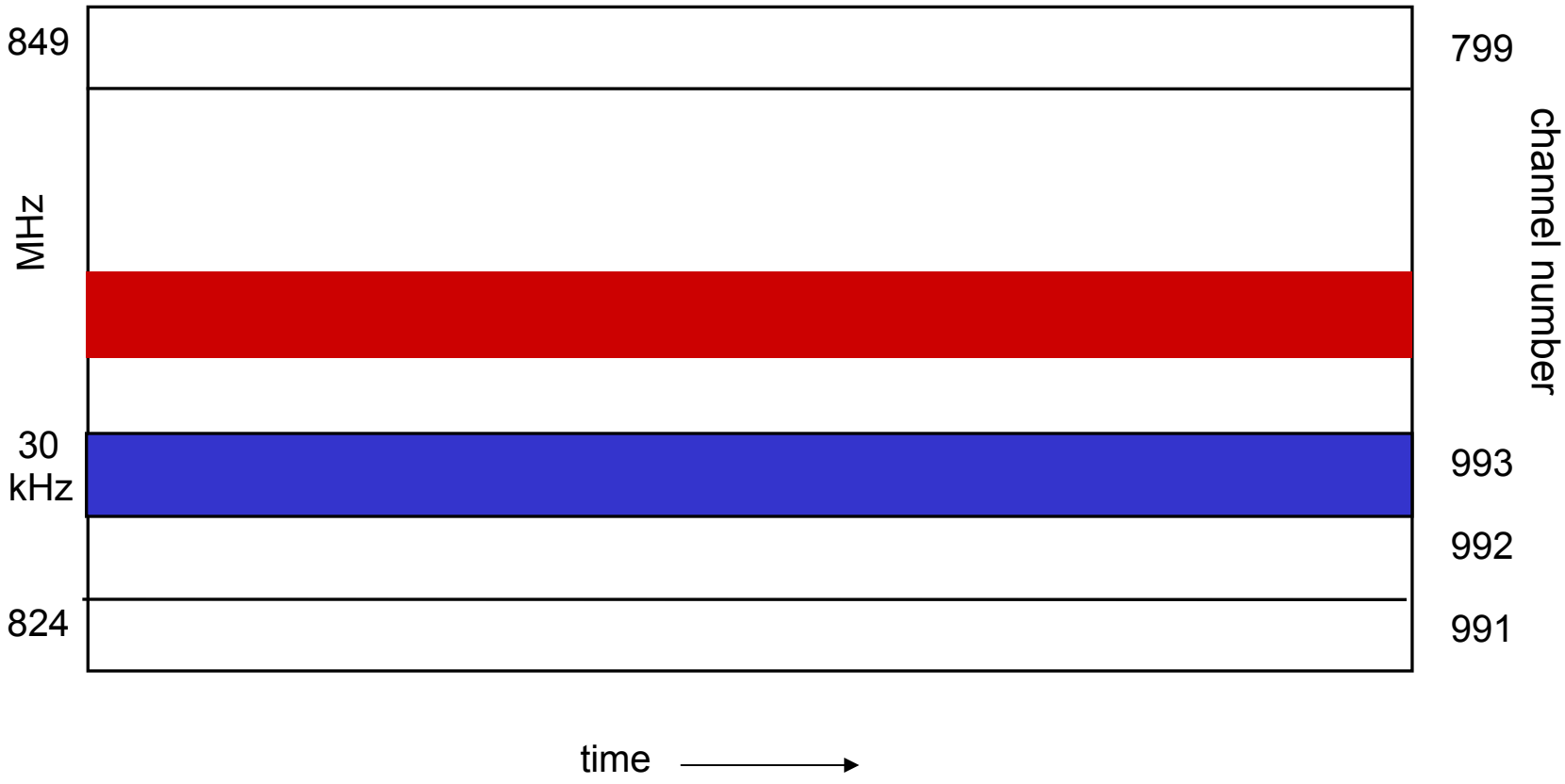
Network Definition



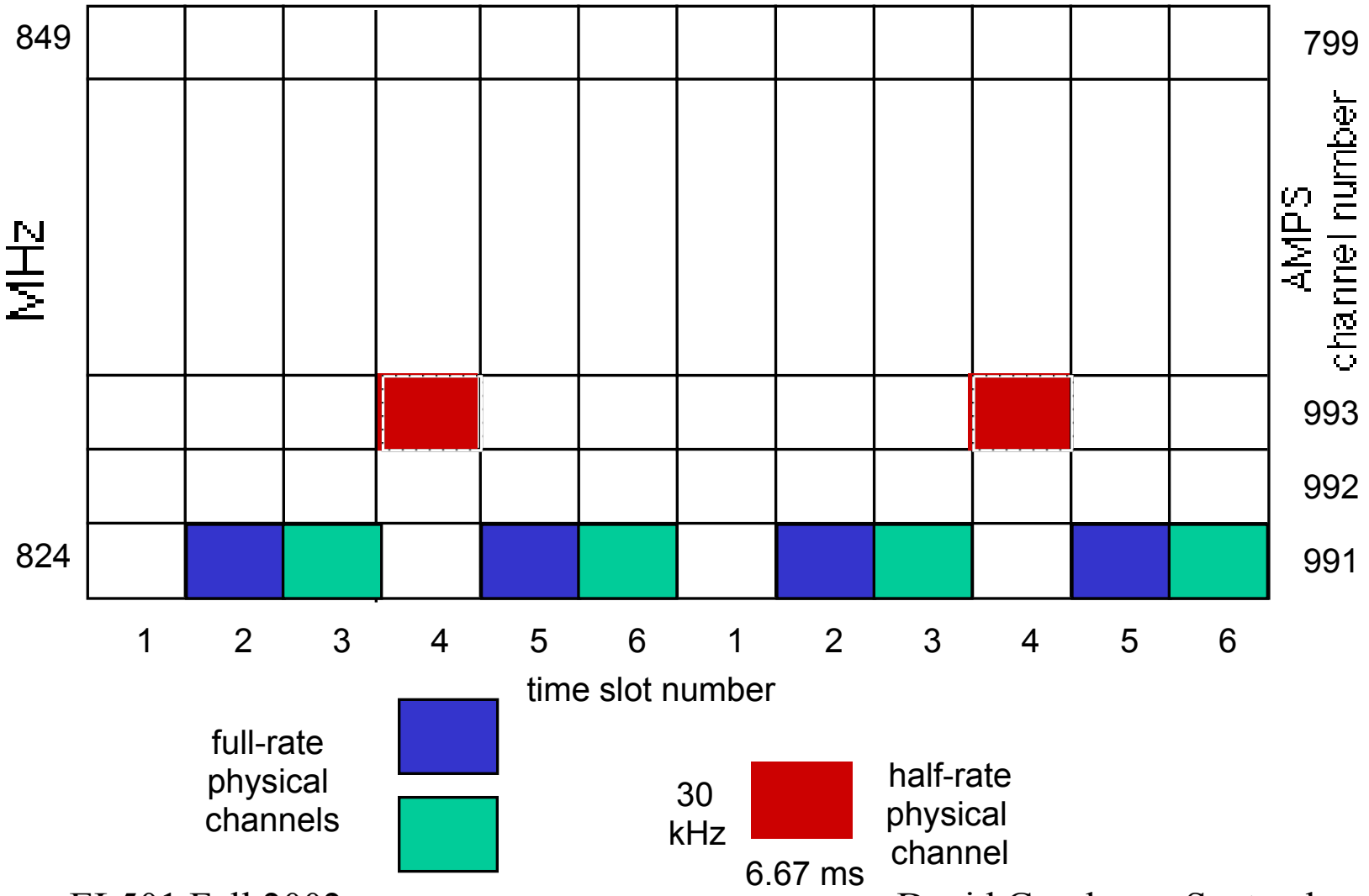
NA-TDMA Identifiers

NOTATION	NAME	SIZE BITS	DESCRIPTION
MIN	Mobile identifier	34	Directory number assigned by operating company to a subscriber
IMSI	International mobile subscriber identity	50	Directory number conforming to internatior convention
ESN	Electronic serial number	32	Assigned by manufacturer to a mobile station
A	A key	64	Secret key for cryptographic authentication
SID	System identifier	15	Assigned by regulators to a geographical service area
SCM	Station class mark	5	Indicates capabilities of a mobile station
PV	Protocol version	4	Indicates capabilities of a mobile station or a base station
SAT	Supervisory audio tone	*	Assigned by operating company to each base station
SOC	System operator code	12	Identifies the company operating a particu system
BSMC	Base station manufacturer code	8	Identifies the manufacturer of the local base station
LOCAID	Location area identifier	12	Identifies the location area of a base station
DCC	Digital color code	2	Assigned by operating company to each base station
DVCC	Digital verification color code	12	Assigned by operating company to each base station with digital channels

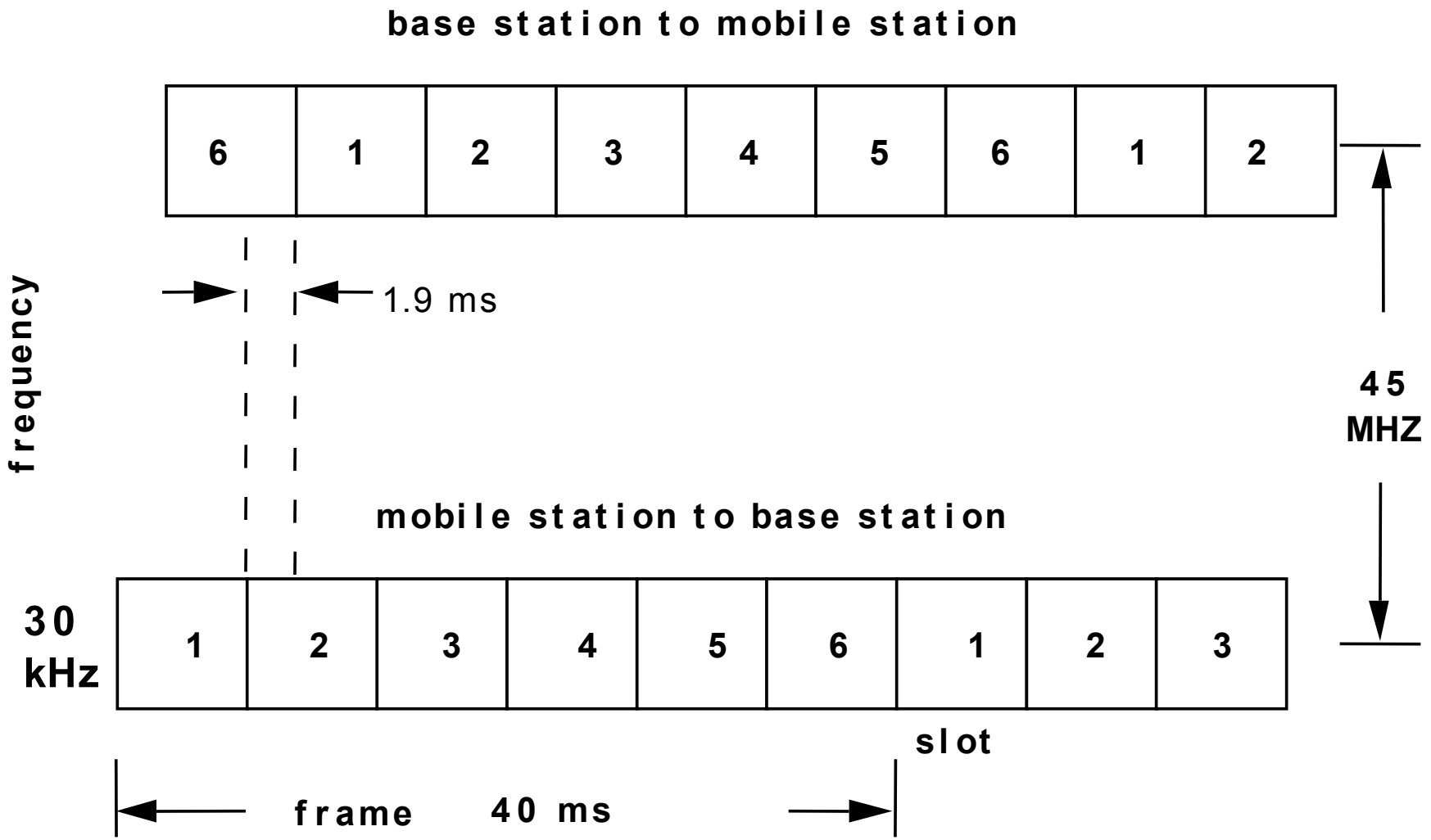
AMPS Physical Channels



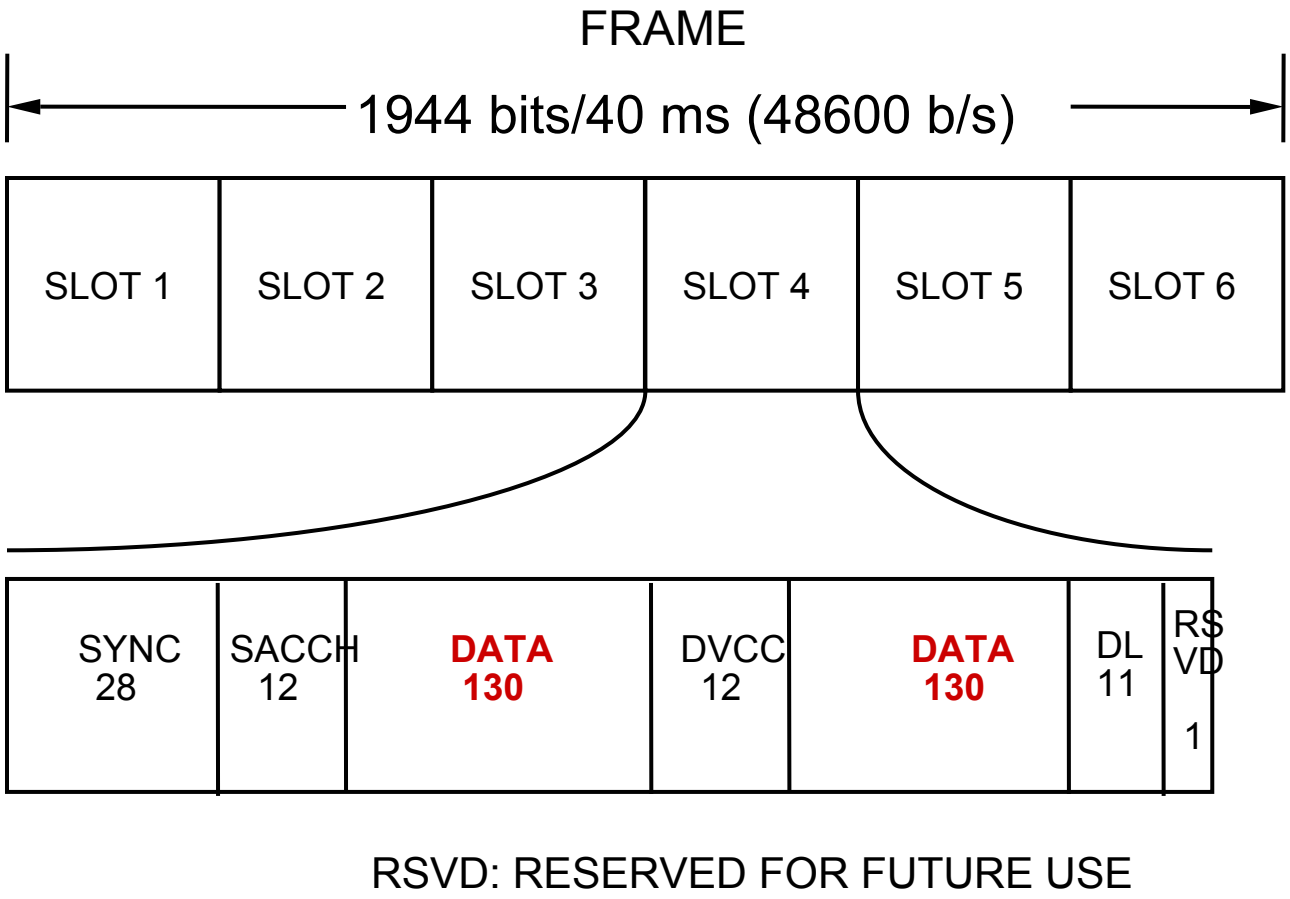
NA-TDMA Physical Channels



Carriers, Frames, Slots



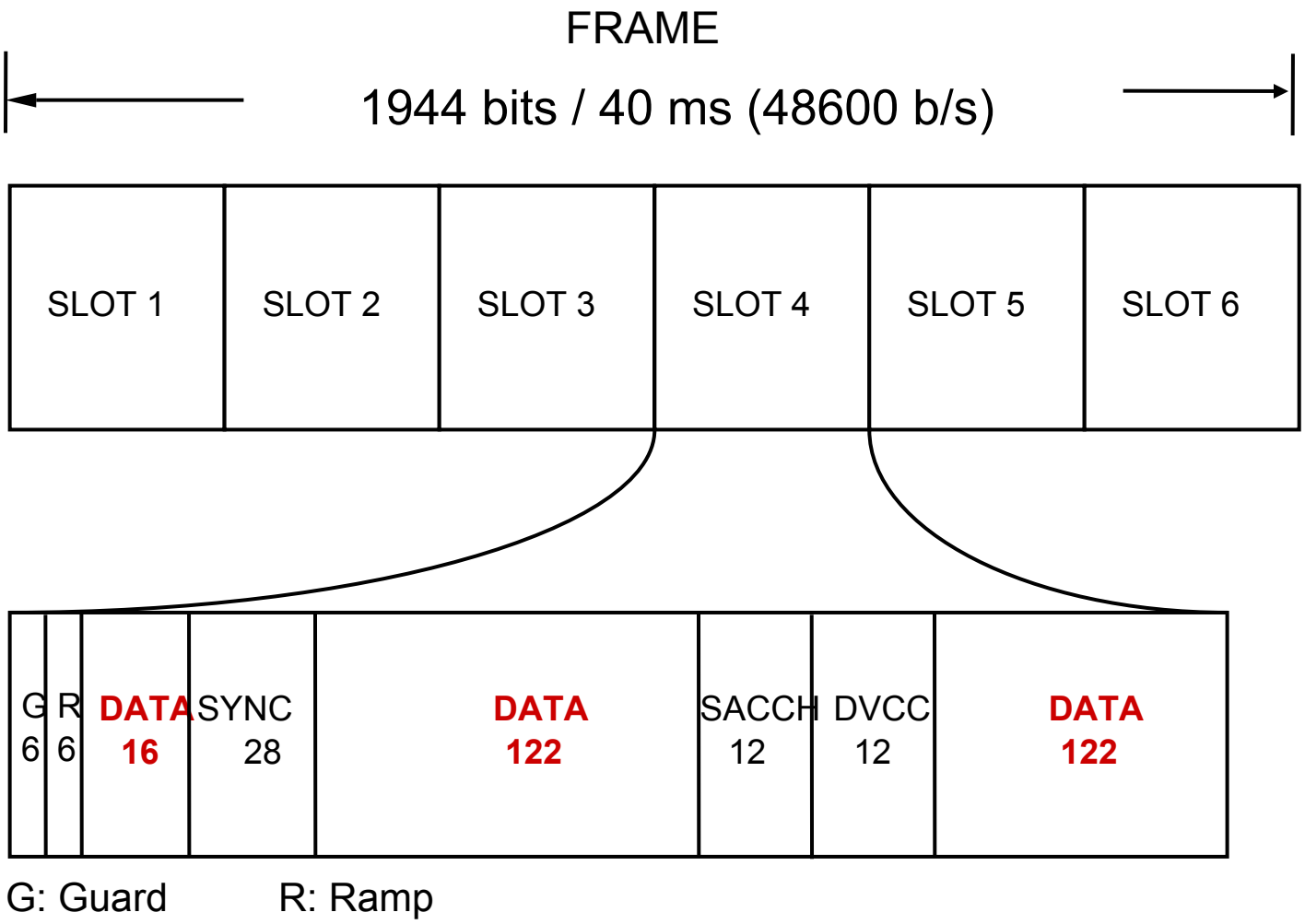
Forward Traffic Channel



RSVD: RESERVED FOR FUTURE USE

260 x 2 data bits/40 ms = 13 kb/s per traffic channel

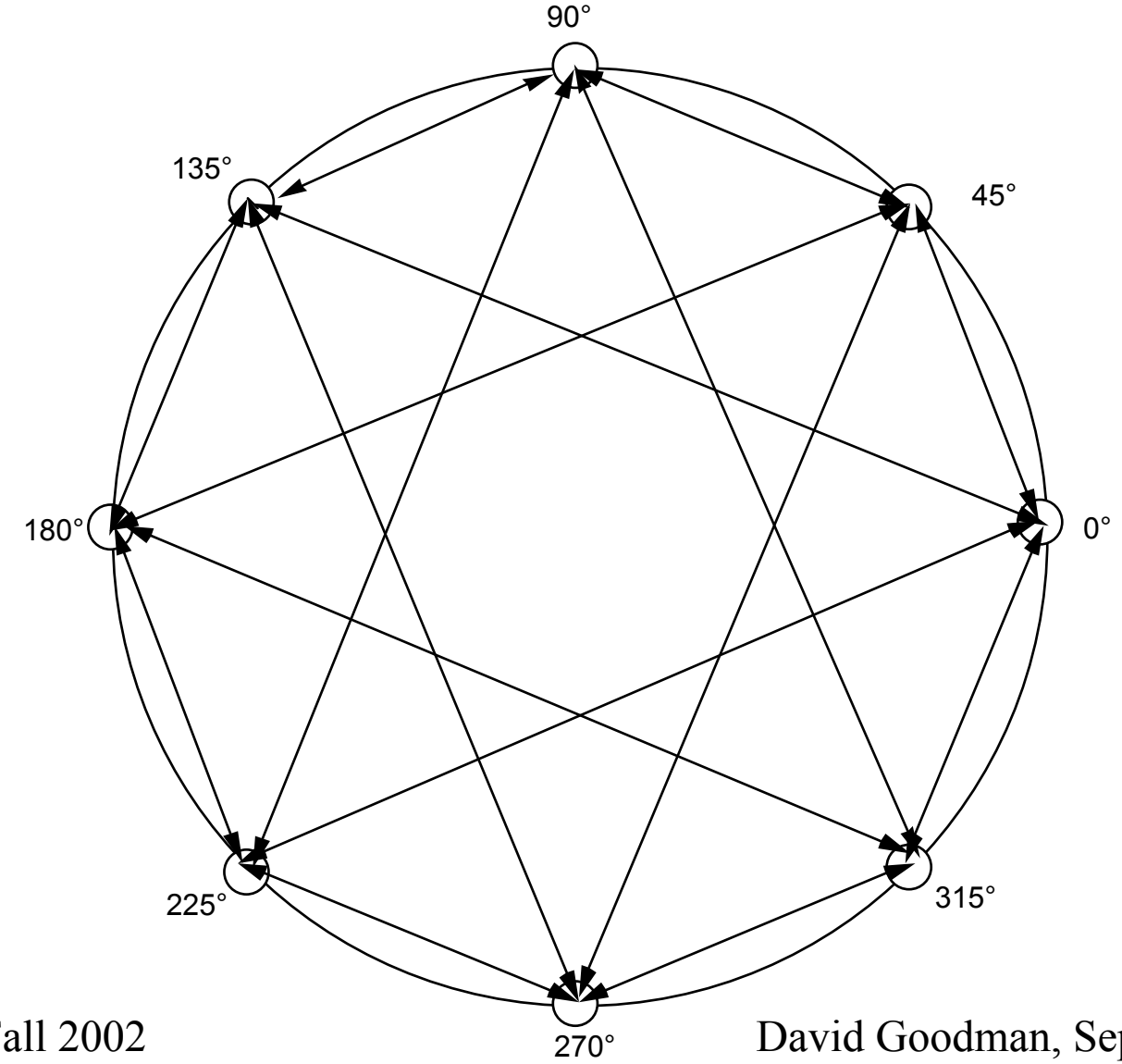
Reverse Traffic Channel



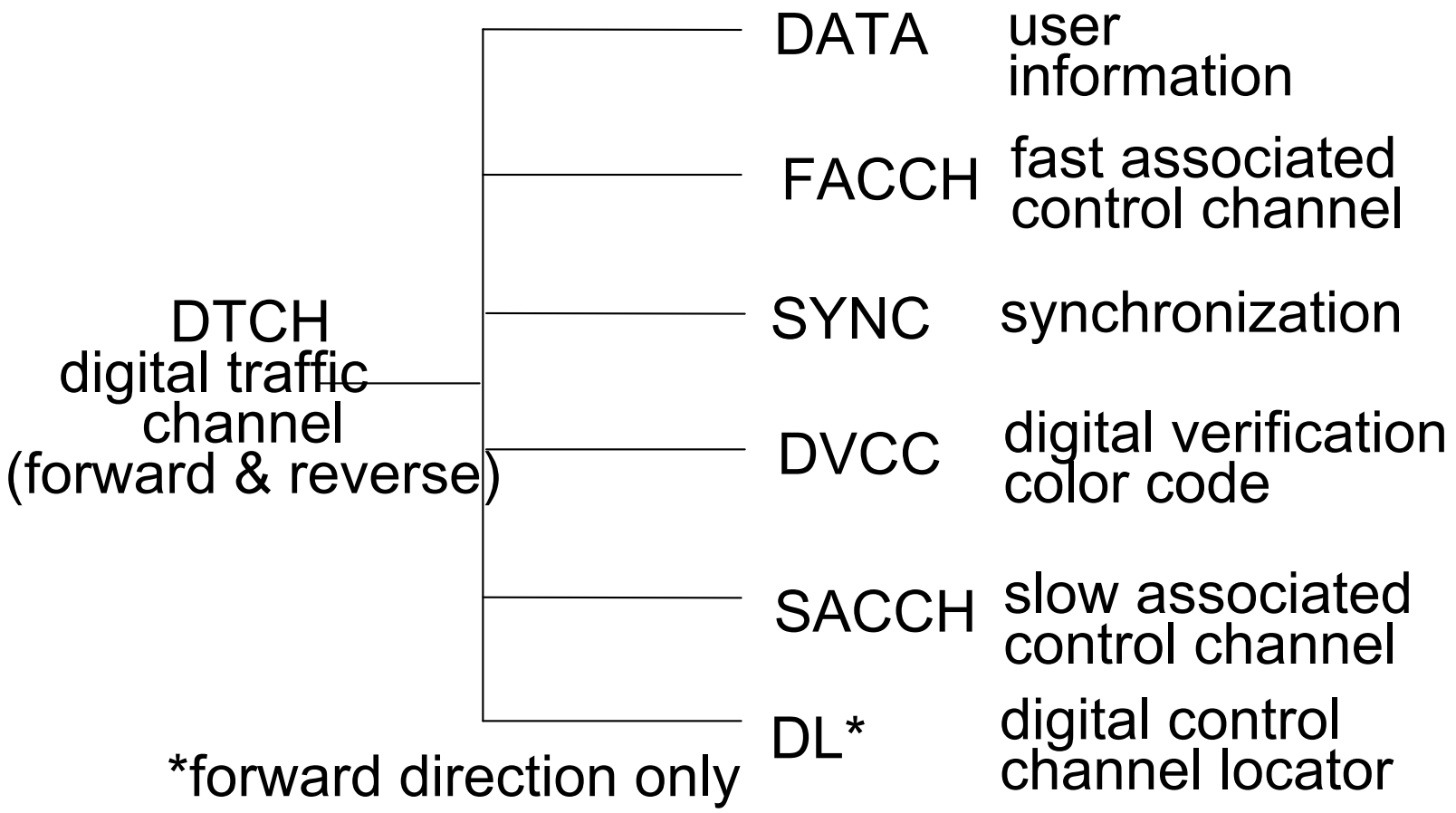
260 x 2 data bits/40 ms = 13 kb/s per traffic channel

DQPSK MODULATION

DIFFERENTIAL QUATERNARY (QUADRATURE?) PHASE SHIFT KEYING



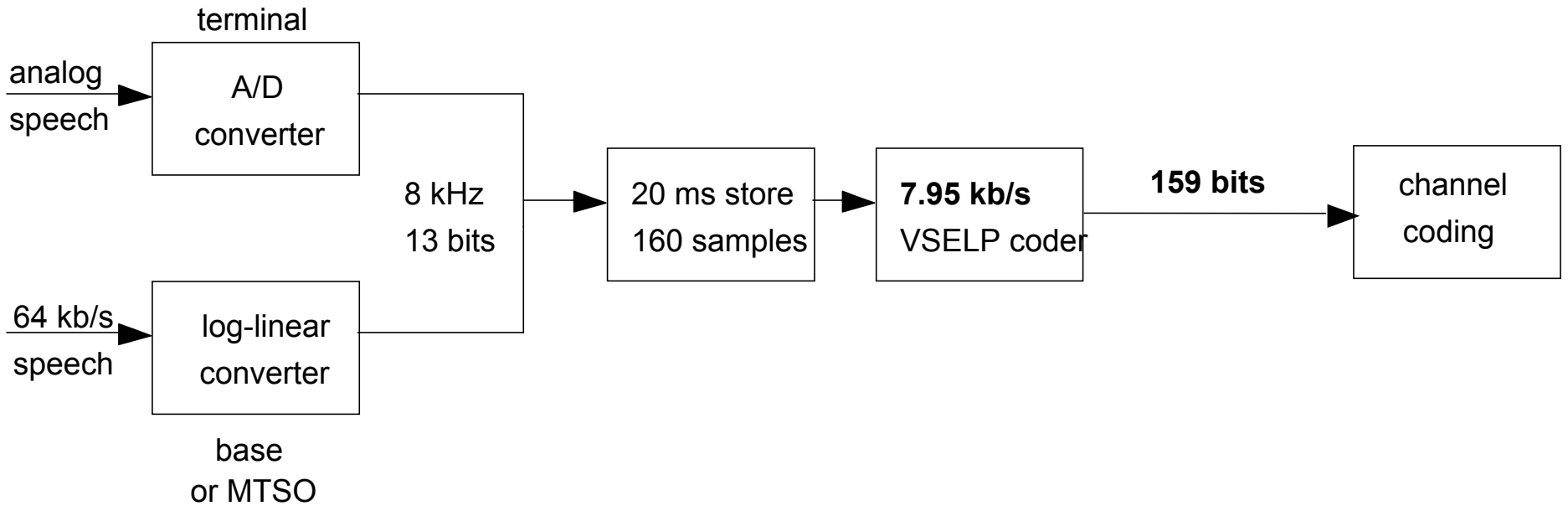
LOGICAL CHANNELS - DTCH



Slot Contents - DTCH

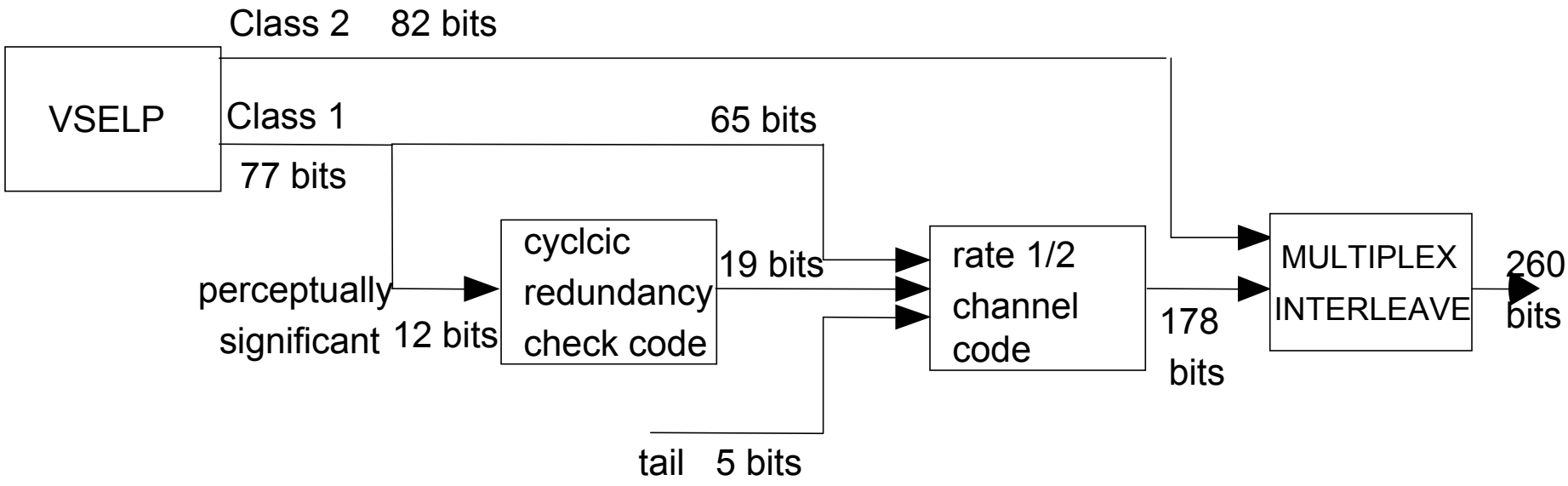
	Length (bits)	Purpose
DATA*	**260**	transport user information
FACCH*	**260**	network control message
DVCC	**12**	lock terminal to correct base station
SYNC	**28**	frame synchronization; lock terminal to correct time slot
SACCH	12	network control message
DL	**11 (forward)**	information about location of DTCH
RSVD	**1 (forward)**	always set to zero

Speech compression
(VSELP)



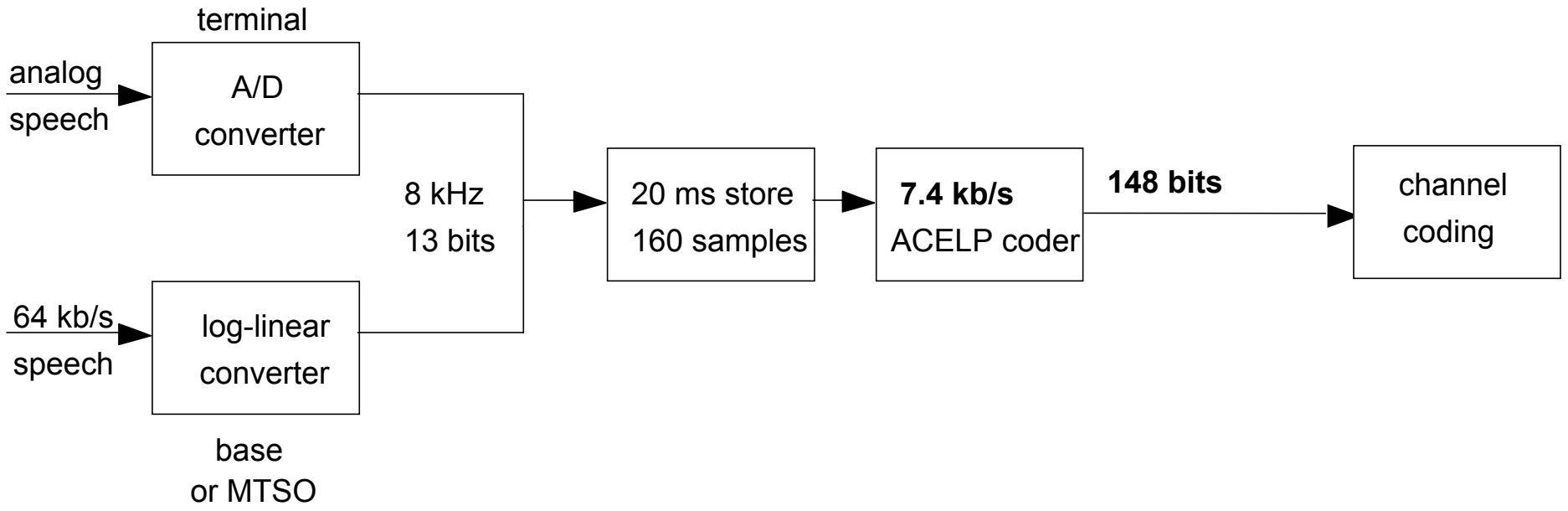
159 bits in 20 ms = 7.95 kb/s

Coding of VSELP speech



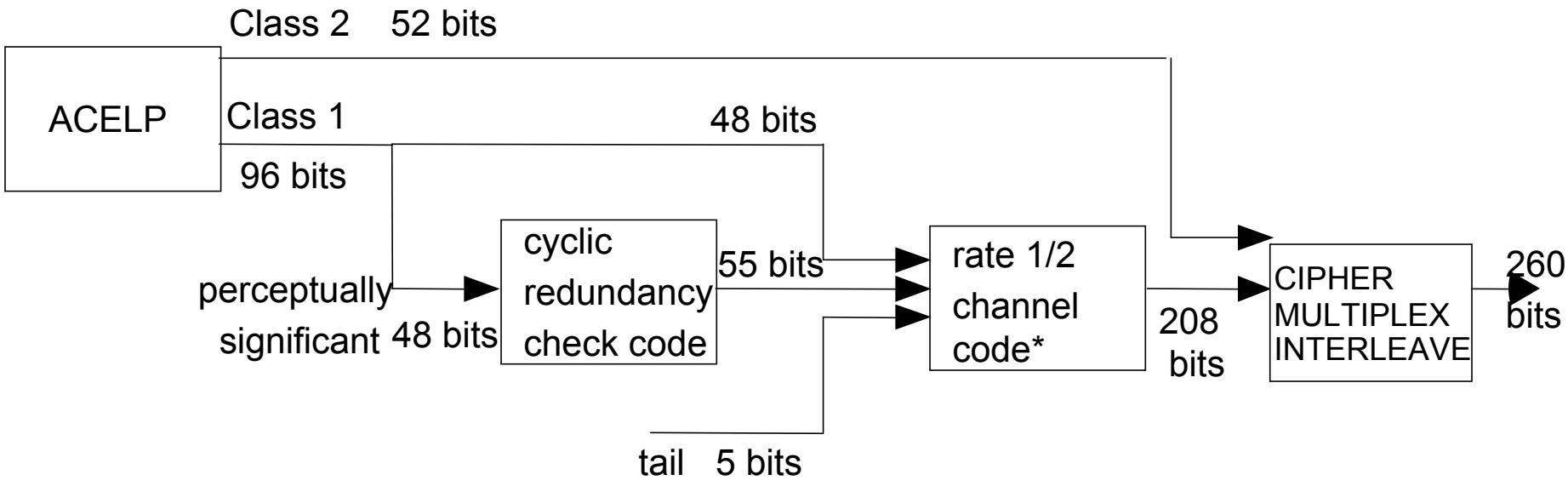
260 bits in 20 ms = 13 kb/s

Speech compression
(ACELP aka Enhanced Full Rate)



148 bits in 20 ms = 7.4 kb/s

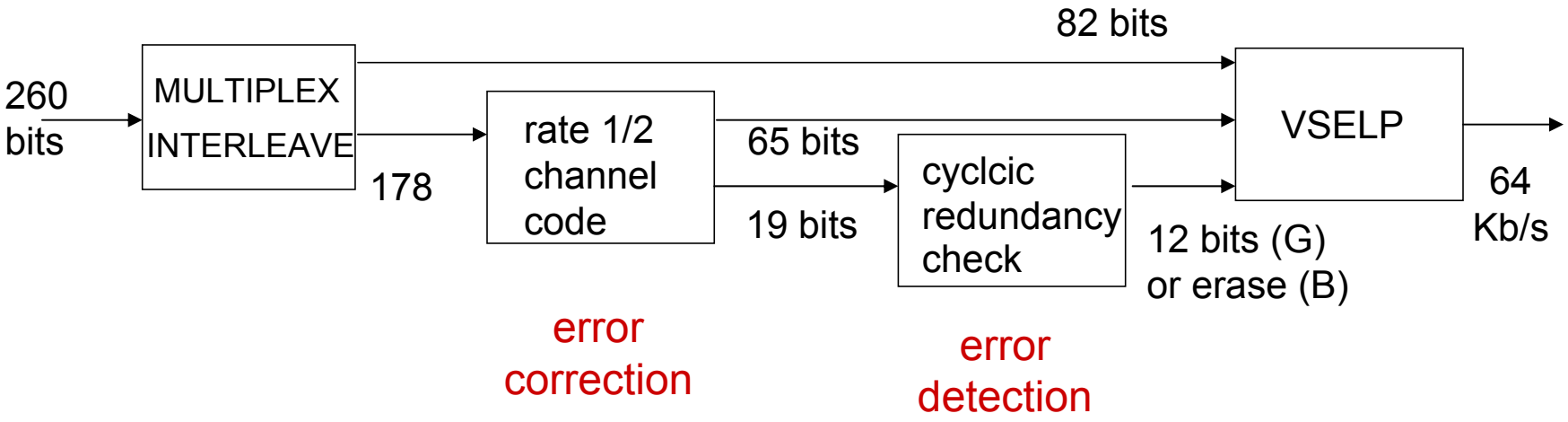
Coding of ACELP speech



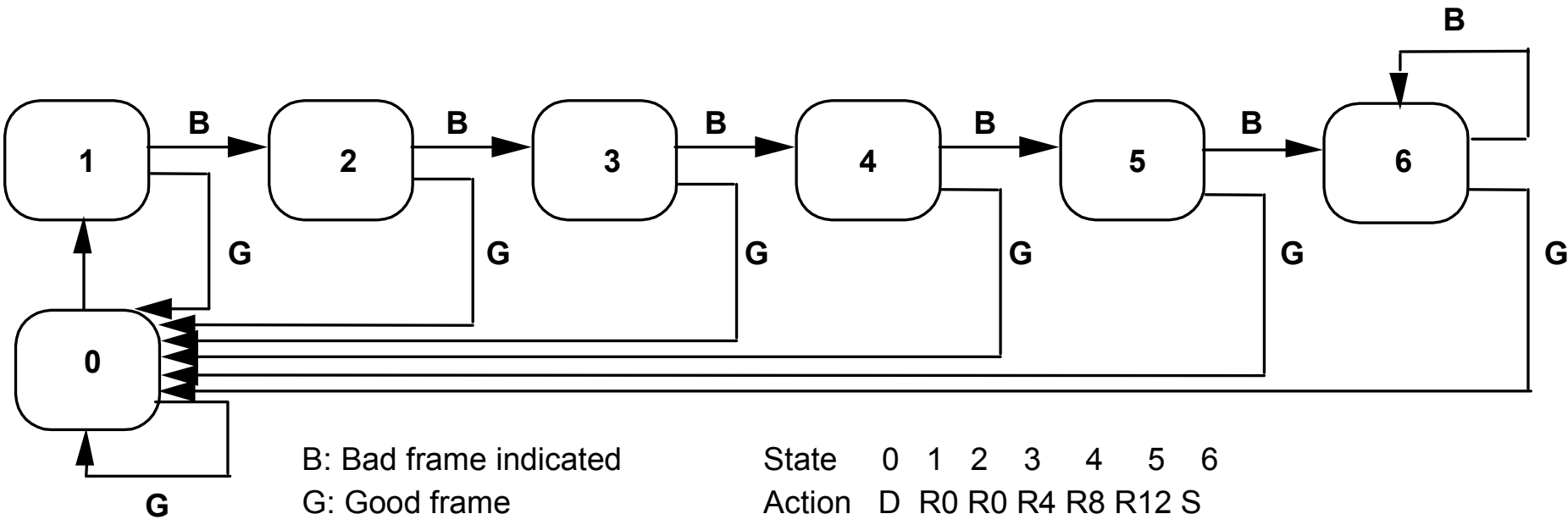
*the 216 bits of the code are punctured (8-bits deleted) to produce 208 bits total

260 bits in 20 ms = 13 kb/s

Decoding of VSELP speech



Estimate missing speech frames

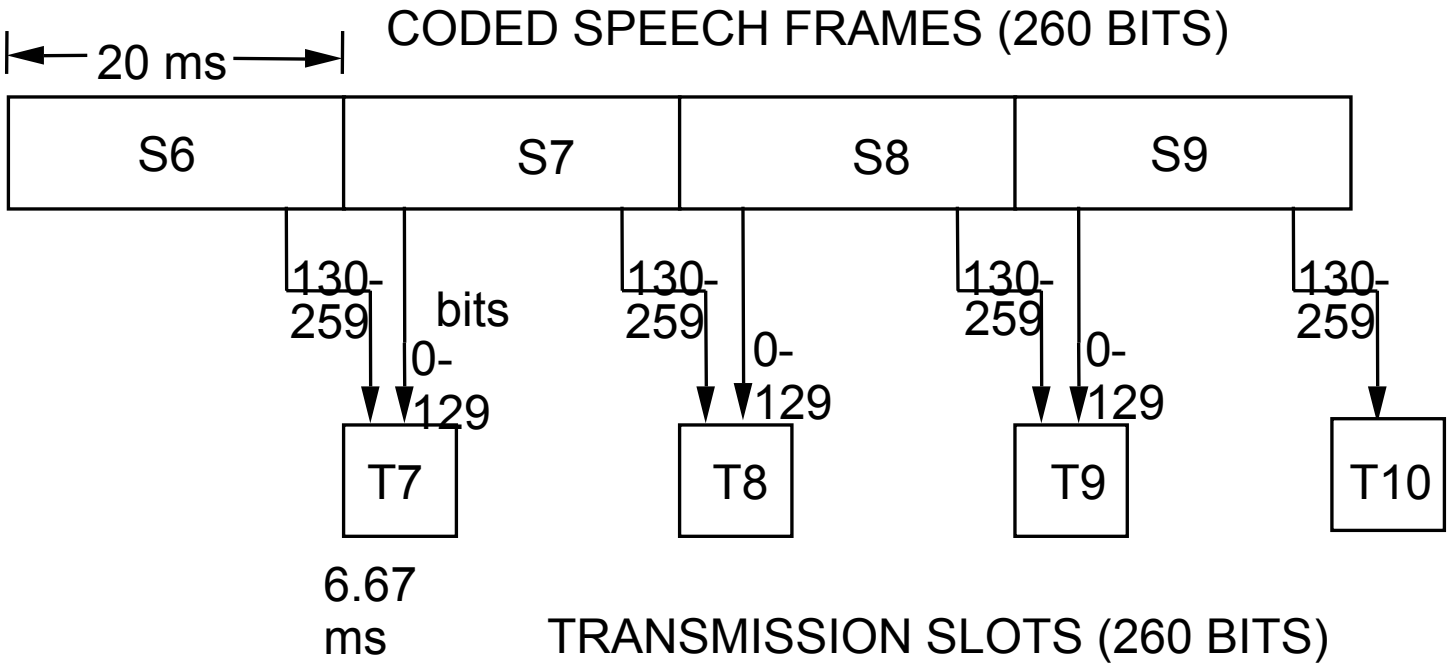


B: Bad frame indicated
G: Good frame

State	0	1	2	3	4	5	6
Action	D	R0	R0	R4	R8	R12	S

D: decode received bits
Rn: repeat previous block with n dB attenuation
S: silent speech output

Assemble traffic channel time slots



Speech interleaving

130					
000					

Speech interleaving

130					
000					
131					
001					

Speech interleaving

130					
000					
131					
001					
142					
012					

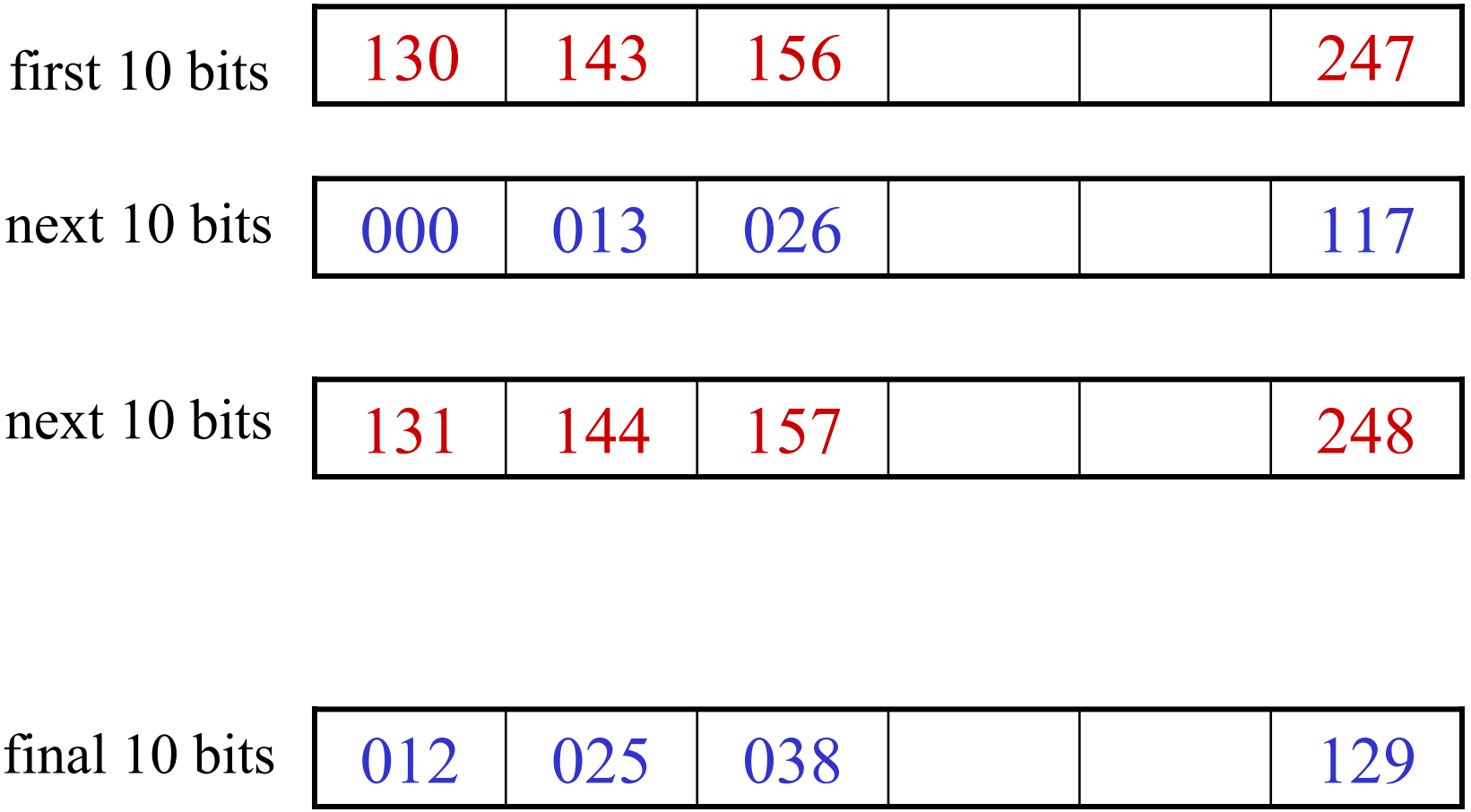
Speech interleaving

130	143				
000	013				
131	144				
001	014				
142	155				
012	025				

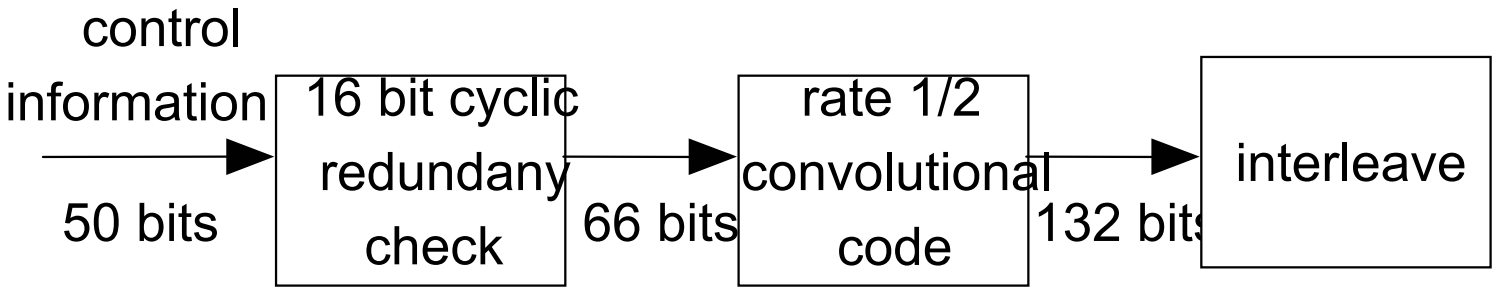
Speech interleaving

130	143	156			247
000	013	026			117
131	144	157			248
001	014	027			118
142	155	168			259
012	025	038			129

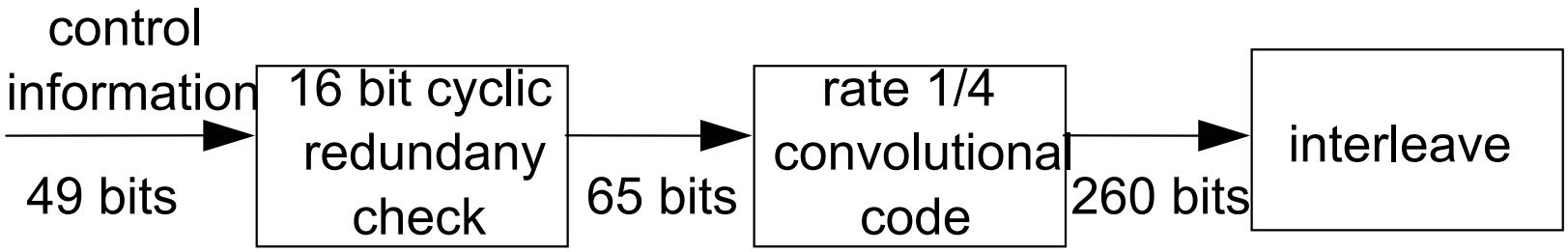
Speech interleaving
transmission sequence



SACCH Coding



FACCH Coding



Associated control channel interleaving

(1) arriving bits

60	61	62	63	64	65	66	67	68	69	70	71

(2) place new bits on the diagonal of a 12 x 12 matrix
(71' indicates bit 71 in previous code word)

60											
49	61										
38	50	62									
27	39	51	63								
16	28	40	52	64							
5	17	29	41	53	65						
126'	6	18	30	42	54	66					
115'	127'	7	19	31	43	55	67				
104'	116'	128'	8	20	32	44	46	68			
93'	105'	117'	129'	9	21	33	45	57	69		
82'	94'	106'	118'	130'	10	22	34	46	58	70	
71'	83'	95'	107'	119'	131'	11	23	35	47	59	71

(3) transmit bits in the first column of the matrix

71'	82'	93'	104'	115'	126'	5	16	27	38	49	60

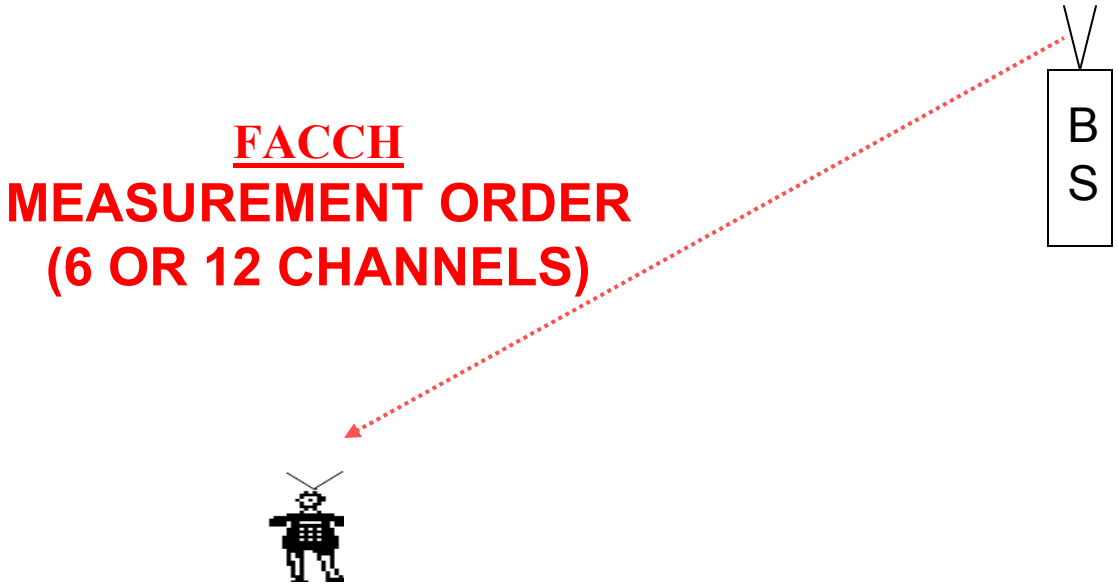
(4) shift the matrix one column to the left

(5) arriving bits

72	73	74	75	76	77	78	79	80	81	82	83

Mobile assisted handoff (MAHO)

request

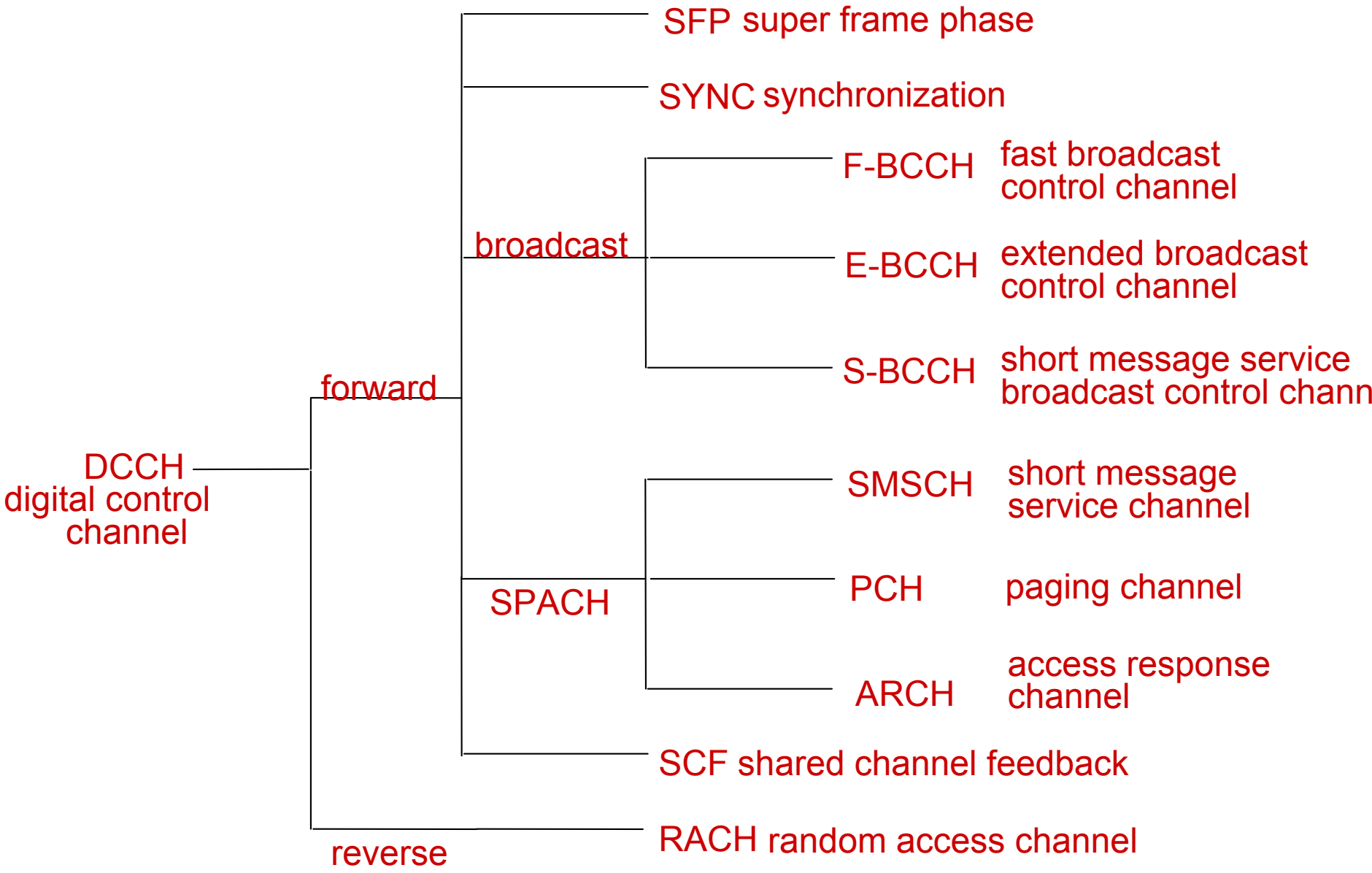


Mobile assisted handoff (MAHO)

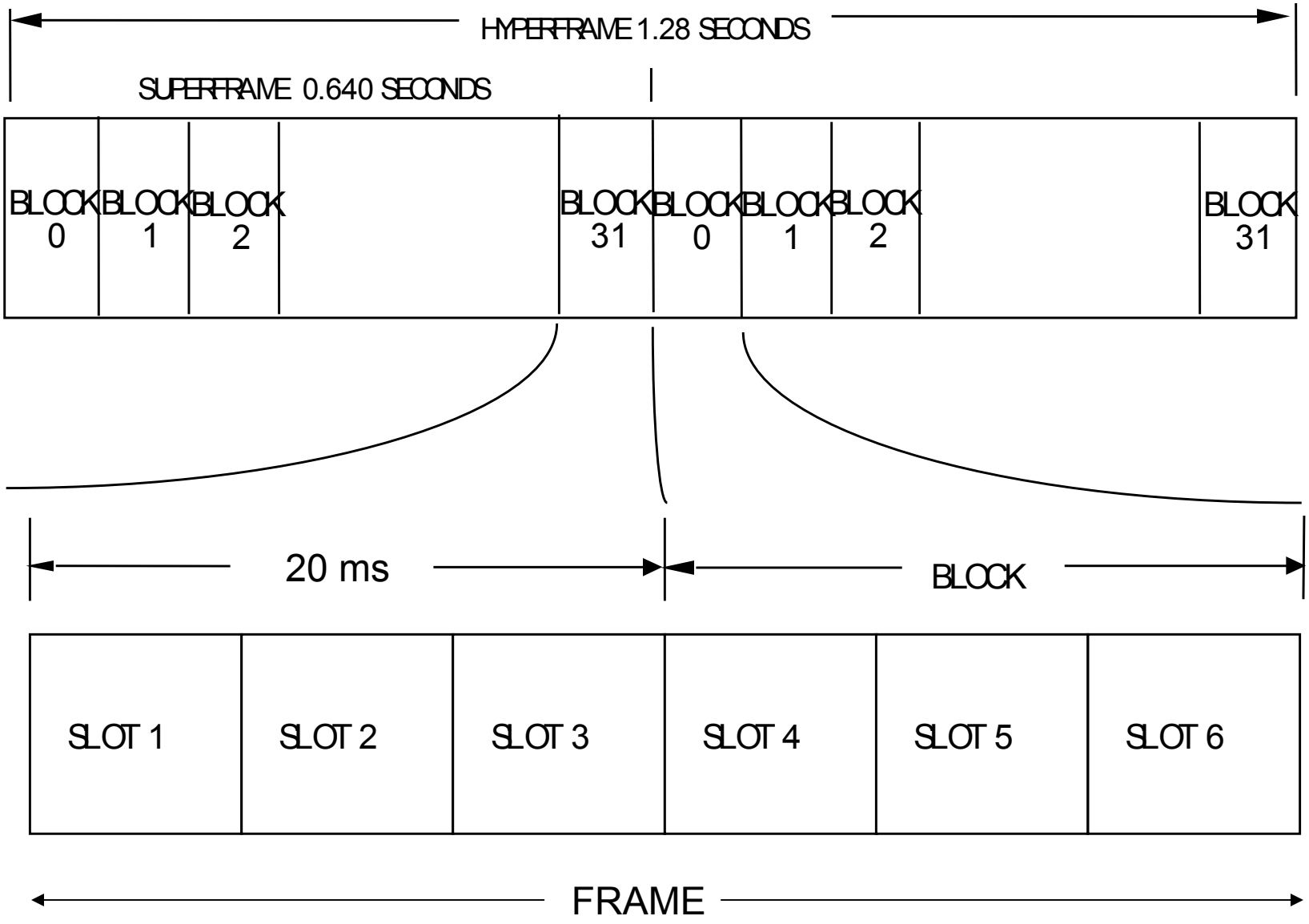
reports

- BER ON DTCH ONLY (3 BITS)
  - 0.0001 TO 0.08
- RSSI ON DTCH & NEIGHBORS (5 BITS)
  - -113 dBm to –51 dBm

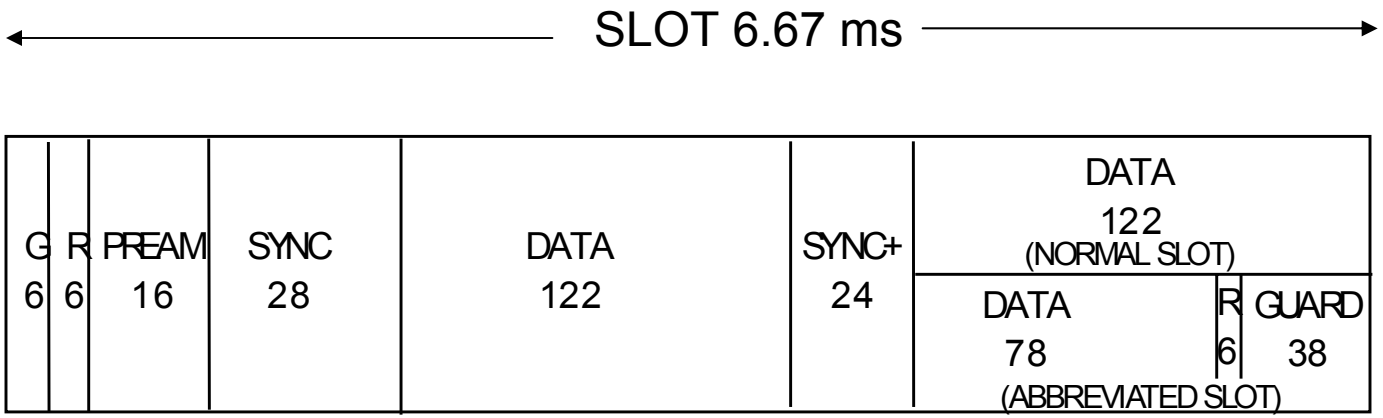
LOGICAL CHANNELS - DCCH



DCCH timing

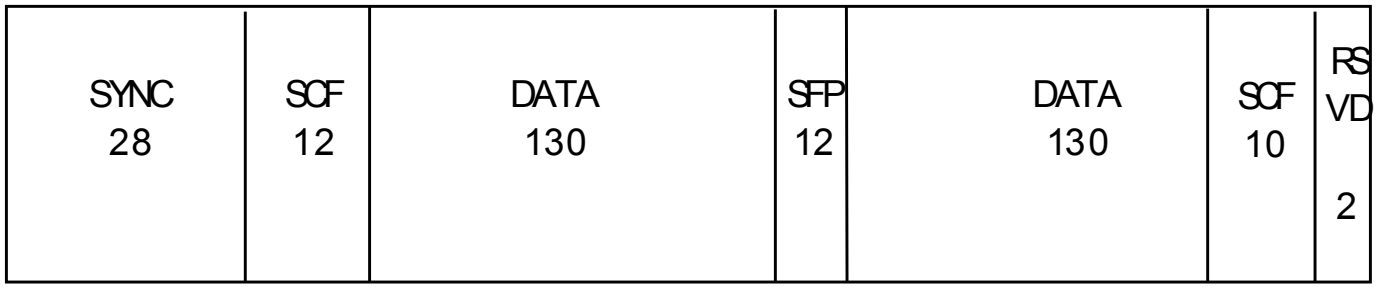

HYPERFRAME 1.28 SECONDS
SUPERFRAME 0.640 SECONDS
BLOCK 0
BLOCK 1
BLOCK 2
BLOCK 31
BLOCK 0
BLOCK 1
BLOCK 2
BLOCK 31
20 ms
BLOCK
SLOT 1
SLOT 2
SLOT 3
SLOT 4
SLOT 5
SLOT 6
FRAME

DCCH bursts



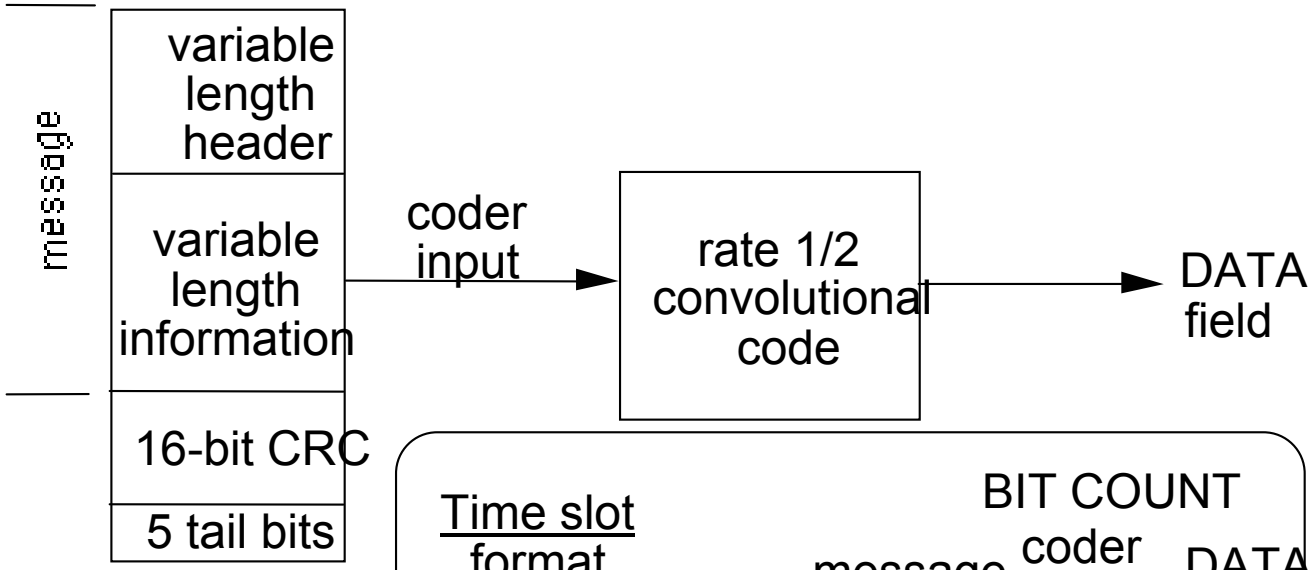
MOBILE TO BASE

G: GUARD TIME, R: RAMP TIME
RSVD: RESERVED FOR FUTURE USE



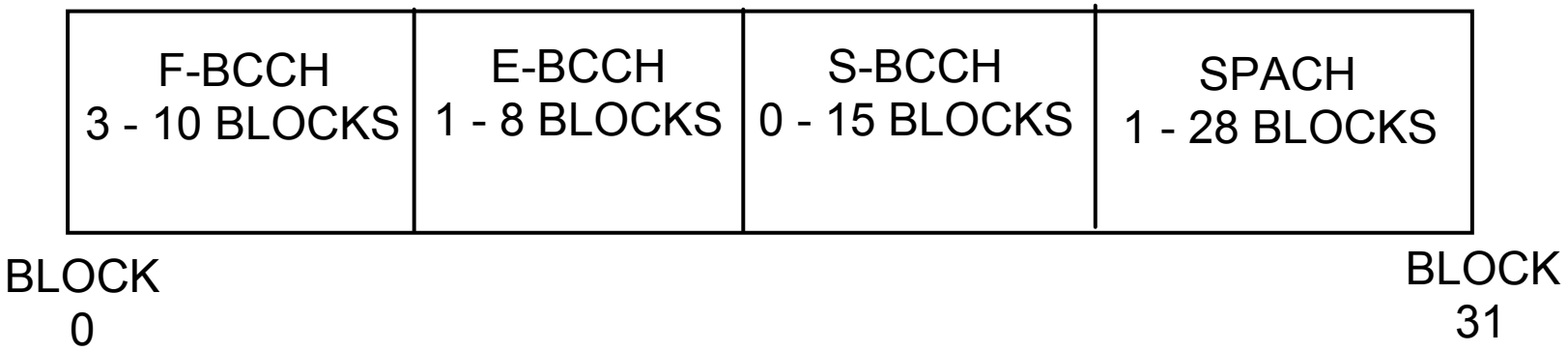
BASE TO MOBILE

DCCH messages



Time slot format	BIT COUNT message	coder input	DATA
Forward DCCH	109	130	260
Normal reverse	101	122	244
Abbreviated reverse	79	100	200

Hyperframe multiplex



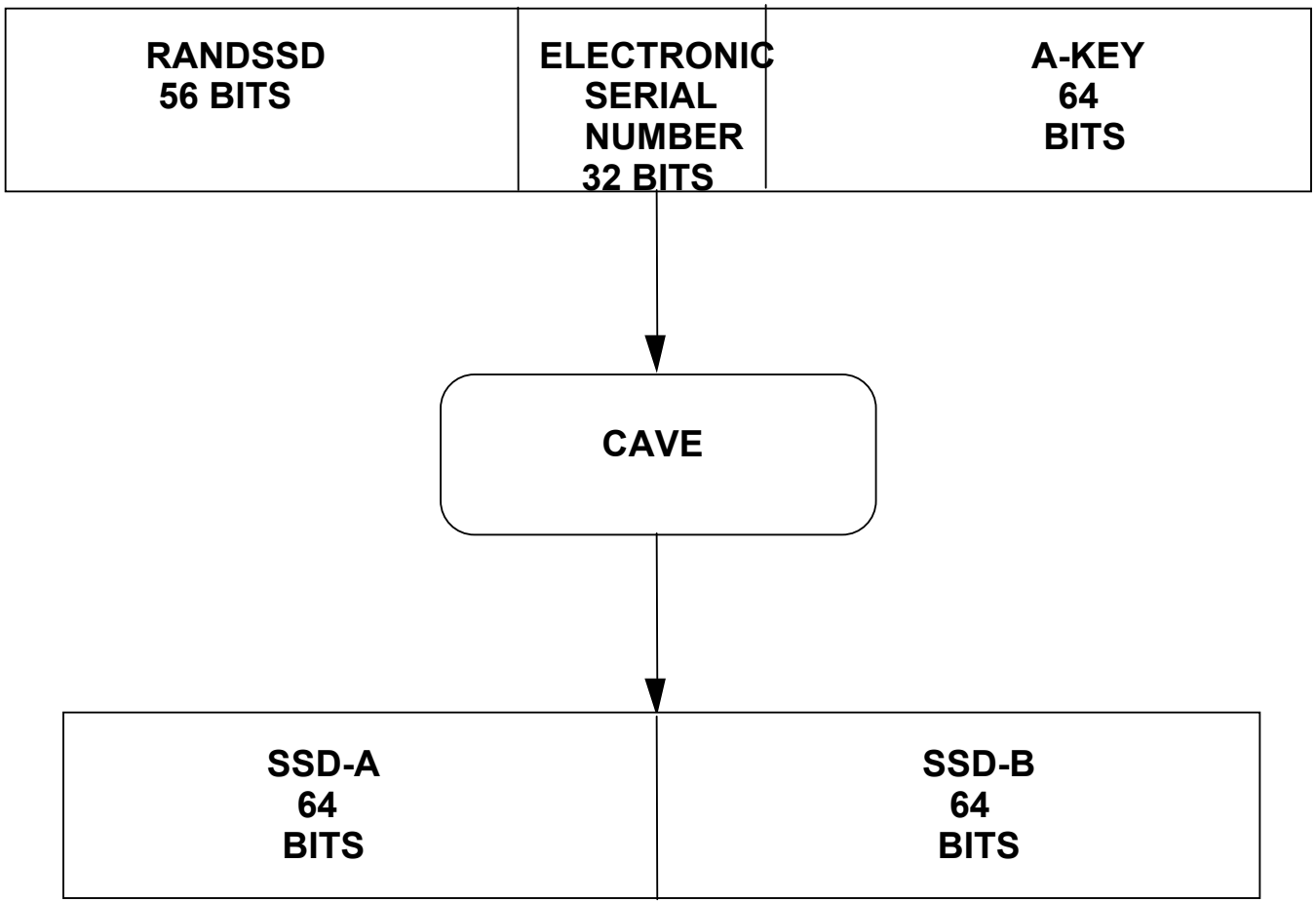
Sleep mode

- Number of paging subchannels = PFN
- Hash your phone number to choose a subchannel
- Power down except when subchannel is active

Network security

- Encryption key (A-key) stored in AC and MS
- A-key is never transmitted.
- Encryption/authentication keys “shared secret data” (SSD) are computed from A-key.
- SSD also depends on an event counter in the MS

Generating encryption keys



Coordinate encryption keys