9 ENCRYPTION KEY SAMPLE DATA

Explanation:

Key [i]: denotes the ith sub-key in Ar or A'r;
round r: denotes the input to the rth round;
added ->: denotes the input to round 3 in A'r after adding original input (of round 1).

9.1 FOUR TESTS OF E1

```
rand    :00000000000000000000000000000000
address :000000000000
key     :00000000000000000000000000000000
round  1:00000000000000000000000000000000
Key [ 1]:00000000000000000000000000000000
Key [ 2]:4697b1baa3b7100ac537b3c95a28ac64
round  2:78d19f9307d2476a523ec7a8a026042a
Key [ 3]:ecabaac66795580df89af66e66dc053d
Key [ 4]:8ac3d8896ae9364943bfebd4969b68a0
round  3:600265247668dda0e81c07bbb30ed503
Key [ 5]:5d57921fd5715cbb22c1be7bbc996394
Key [ 6]:2a61b8343219fdfb1740e6511d41448f
round  4:d7552ef7cc9dbde568d80c2215bc4277
Key [ 7]:dd0480dee731d67f01a2f739da6f23ca
Key [ 8]:3ad01cd1303e12a1cd0fe0a8af82592c
round  5:fb06bef32b52ab8f2a4f2b6ef7f6d0cd
Key [ 9]:7dadb2efc287ce75061302904f2e7233
Key [10]:c08dcfa981e2c4272f6c7a9f52e11538
round  6:b46b711ebb3cf69e847a75f0ab884bdd
Key [11]:fc2042c708e409555e8c147660ffdfd7
Key [12]:fa0b21001af9a6b9e89e624cd99150d2
round  7:c585f308ff19404294f06b292e978994
Key [13]:18b40784ea5ba4c80ecb48694b4e9c35
Key [14]:454d54e5253c0c4a8b3fcca7db6baef4
round  8:2665fadb13acf952bf74b4ab12264b9f
Key [15]:2df37c6d9db52674f29353b0f011ed83
Key [16]:b60316733b1e8e70bd861b477e2456f1
Key [17]:884697b1baa3b7100ac537b3c95a28ac
round  1:158ffe43352085e8a5ec7a88e1ff2ba8
Key [ 1]:e9e5dfc1b3a79583e9e5dfc1b3a79583
Key [ 2]:7595bf57e0632c59f435c16697d4c864
round  2:0b5cc75febcdf7827ca29ec0901b6b5b
Key [ 3]:e31b96afcc75d286ef0ae257cbbc05b7
Key [ 4]:0d2a27b471bc0108c6263aff9d9b3b6b
round  3:e4278526c8429211f7f2f0016220aef4
added ->:f1b68365fd6217f952de6a89831fd95c
Key [ 5]:98d1eb5773cf59d75d3b17b3bc37c191
Key [ 6]:fd2b79282408ddd4ea0aa7511133336f
round  4:d0304ad18337f86040145d27aa5c8153
Key [ 7]:331227756638a41d57b0f7e071ee2a98
```

```
Key [ 8]:aa0dd8cc68b406533d0f1d64aabacf20
round  5:84db909d213bb0172b8b6aaf71bf1472
Key [ 9]:669291b0752e63f806fce76f10e119c8
Key [10]:ef8bdd46be8ee0277e9b78adef1ec154
round  6:f835f52921e903dfa762f1df5abd7f95
Key [11]:f3902eb06dc409cfd78384624964bf51
Key [12]:7d72702b21f97984a721c99b0498239d
round  7:ae6c0b4bb09f25c6a5d9788a31b605d1
Key [13]:532e60bceaf902c52a06c2c283ecfa32
Key [14]:181715e5192efb2a64129668cf5d9dd4
round  8:744a6235b86cc0b853cc9f74f6b65311
Key [15]:83017c1434342d4290e961578790f451
Key [16]:2603532f365604646ff65803795ccce5
Key [17]:882f7c907b565ea58dae1c928a0dcf41
sres    :056c0fe6
aco     :48afcdd4bd40fef76693b113
----------------------------------------
rand    :bc3f30689647c8d7c5a03ca80a91eceb
address :7ca89b233c2d
key     :159dd9f43fc3d328efba0cd8a861fa57
round  1:bc3f30689647c8d7c5a03ca80a91eceb
Key [ 1]:159dd9f43fc3d328efba0cd8a861fa57
Key [ 2]:326558b3c15551899a97790e65ff669e
round  2:3e950edf197615638cc19c09f8fedc9b
Key [ 3]:62e879b65b9f53bbfbd020c624b1d682
Key [ 4]:73415f30bac8ab61f410adc9442992db
round  3:6a7640791cb536678936c5ecd4ae5a73
Key [ 5]:5093cfa1d31c1c48acd76df030ea3c31
Key [ 6]:0b4acc2b8f1f694fc7bd91f4a70f3009
round  4:fca2c022a577e2ffb2aa007589693ec7
Key [ 7]:2ca43fc817947804ecff148d50d6f6c6
Key [ 8]:3fcd73524b533e00b7f7825bea2040a4
round  5:e97f8ea4ed1a6f4a36ffc179dc6bb563
Key [ 9]:6c67bec76ae8c8cc4d289f69436d3506
Key [10]:95ed95ee8cb97e61d75848464bffb379
round  6:38b07261d7340d028749de1773a415c7
Key [11]:ff566c1fc6b9da9ac502514550f3e9d2
Key [12]:ab5ce3f5c887d0f49b87e0d380e12f47
round  7:58241f1aed7c1c3e047d724331a0b774
Key [13]:a2cab6f95eac7d655dbe84a6cd4c47f5
Key [14]:f5caff88af0af8c42a20b5bbd2c8b460
round  8:3d1aaeff53c0910de63b9788b13c490f
Key [15]:185099c1131cf97001e2f36fda415025
Key [16]:a0ebb82676bc75e8378b189eff3f6b1d
Key [17]:cf5b348aaee27ae332b4f1bfa10289a6
round  1:2e4b417b9a2a9cfd7d8417d9a6a556eb
Key [ 1]:fe78b835f26468ab069fd3991b086fda
Key [ 2]:095c5a51c6fa6d3ac1d57fa19aa382bd
round  2:b8bca81d6bb45af9d92beadd9300f5ed
Key [ 3]:1af866df817fd9f4ec00bc704192cffc
Key [ 4]:f4a8a059c1f575f076f5fbb24bf16590
round  3:351aa16dec2c3a4787080249ed323eae
```

```
added ->:1b65e2167656d6bafa8c19904bd79445
Key [ 5]:8c9d18d9356a9954d341b4286e88ea1f
Key [ 6]:5c958d370102c9881bf753e69c7da029
round  4:2ce8fef47dda6a5bee74372e33e478a2
Key [ 7]:7eb2985c3697429fbe0da334bb51f795
Key [ 8]:af900f4b63a1138e2874bfb7c628b7b8
round  5:572787f563e1643c1c862b7555637fb4
Key [ 9]:834c8588dd8f3d4f31117a488420d69b
Key [10]:bc2b9b81c15d9a80262f3f48e9045895
round  6:16b4968c5d02853c3a43aa4cdb5f26ac
Key [11]:f08608c9e39ad3147cba61327919c958
Key [12]:2d4131decf4fa3a959084714a9e85c11
round  7:10e4120c7cccef9dd4ba4e6da8571b01
Key [13]:c934fd319c4a2b5361fa8eef05ae9572
Key [14]:4904c17aa47868e40471007cde3a97c0
round  8:f9081772498fed41b6ffd72b71fcf6c6
Key [15]:ea5e28687e97fa3f833401c86e6053ef
Key [16]:1168f58252c4ecfccafbdb3af857b9f2
Key [17]:b3440f69ef951b78b5cbd6866275301b
sres    :8d5205c5
aco     :3ed75df4abd9af638d144e94
----------------------------------------
rand    :0891caee063f5da1809577ff94ccdcfb
address :c62f19f6ce98
key     :45298d06e46bac21421ddfbed94c032b
round  1:0891caee063f5da1809577ff94ccdcfb
Key [ 1]:45298d06e46bac21421ddfbed94c032b
Key [ 2]:8f03e1e1fe1c191cad35a897bc400597
round  2:1c6ca013480a685c1b28e0317f7167e1
Key [ 3]:4f2ce3a092dde854ef496c8126a69e8e
Key [ 4]:968caee2ac6d7008c07283daec67f2f2
round  3:06b4915f5fcc1fc551a52048f0af8a26
Key [ 5]:ab0d5c31f94259a6bf85ee2d22edf56c
Key [ 6]:dfb74855c0085ce73dc17b84bfd50a92
round  4:077a92b040acc86e6e0a877db197a167
Key [ 7]:8f888952662b3db00d4e904e7ea53b5d
Key [ 8]:5e18bfcc07799b0132db88cd6042f599
round  5:7204881fb300914825fdc863e8ceadf3
Key [ 9]:bfca91ad9bd3d1a06c582b1d5512dddf
Key [10]:a88bc477e3fa1d5a59b5e6cf793c7a41
round  6:27031131d86cea2d747deb4f756143aa
Key [11]:f3cfb8dac8aea2a6a8ef95af3a2a2767
Key [12]:77beb90670c5300b03aa2b2232d3d40c
round  7:fc8c13d49149b1ce8d86f96e44a00065
Key [13]:b578373650af36a06e19fe335d726d32
Key [14]:6bcee918c7d0d24dfdf42237fcf99d53
round  8:04ef5f5a7ddf846cda0a07782fc23866
Key [15]:399f158241eb3e079f45d7b96490e7ea
Key [16]:1bcfbe98ecde2add52aa63ea79fb917a
Key [17]:ee8bc03ec08722bc2b075492873374af
round  1:d989d7a40cde7032d17b52f8117b69d5
Key [ 1]:2ecc6cc797cc41a2ab02007f6af396ae
```

```
Key [ 2]:acfaef7609c12567d537ae1cf9dc2198
round  2:8e76eb9a29b2ad5eea790db97aee37c1
Key [ 3]:079c8ff9b73d428df879906a0b87a6c8
Key [ 4]:19f2710baf403a494193d201f3a8c439
round  3:346bb7c35b2539676375aafe3af69089
added ->:edf48e675703a955b2f0fc062b71f95c
Key [ 5]:d623a6498f915cb2c8002765247b2f5a
Key [ 6]:900109093319bc30108b3d9434a77a72
round  4:fafb6c1f3ebbd2477be2da49dd923f69
Key [ 7]:e28e2ee6e72e7f4e5b5c11f10d204228
Key [ 8]:8e455cd11f8b9073a2dfa5413c7a4bc5
round  5:7c72230df588060a3cf920f9b0a08f06
Key [ 9]:28afb26e2c7a64238c41cefc16c53e74
Key [10]:d08dcafc2096395ba0d2dddd0e471f4d
round  6:55991df991db26ff00073a12baa3031d
Key [11]:fcffdcc3ad8faae091a7055b934f87c1
Key [12]:f8df082d77060252c02d91e55bd6a7d6
round  7:70ec682ff864375f63701fa4f6be5377
Key [13]:bef3706e523d708e8a44147d7508bc35
Key [14]:3e98ab283ca2422d56a56cf8b06caeb3
round  8:172f12ec933da85504b4ea5c90f8f0ea
Key [15]:87ad9625d06645d22598dd5ef811ea2c
Key [16]:8bd3db0cc8168009e5da90877e13a36f
Key [17]:0e74631d813a8351ac7039b348c41b42
sres    :00507e5f
aco     :2a5f19fbf60907e69f39ca9f
----------------------------------------
rand    :0ecd61782b4128480c05dc45542b1b8c
address :f428f0e624b3
key     :35949a914225fabad91995d226de1d92
round  1:0ecd61782b4128480c05dc45542b1b8c
Key [ 1]:35949a914225fabad91995d226de1d92
Key [ 2]:ea6b3dcccc8ee5d88de349fa5010404f
round  2:8935e2e263fbc4b9302cabdfc06bce3e
Key [ 3]:920f3a0f2543ce535d4e7f25ad80648a
Key [ 4]:ad47227edf9c6874e80ba80ebb95d2c9
round  3:b4c8b878675f184a0c72f3dab51f8f05
Key [ 5]:81a941ca7202b5e884ae8fa493ecac3d
Key [ 6]:bcde1520bee3660e86ce2f0fb78b9157
round  4:77ced9f2fc42bdd5c6312b87fc2377c5
Key [ 7]:c8eee7423d7c6efa75ecec0d2cd969d3
Key [ 8]:910b3f838a02ed441fbe863a02b4a1d0
round  5:fe28e8056f3004d60bb207e628b39cf2
Key [ 9]:56c647c1e865eb078348962ae070972d
Key [10]:883965da77ca5812d8104e2b640aec0d
round  6:1f2ba92259d9e88101518f145a33840f
Key [11]:61d4cb7e4f8868a283327806a9bd8d4d
Key [12]:9f57de3a3ff310e21dc1e696ce060304
round  7:cc9b5d0218d29037e88475152ebebb2f
Key [13]:7aa1d8adc1aeed7127ef9a18f6eb2d8e
Key [14]:b4db9da3bf865912acd14904c7f7785d
round  8:b04d352bedc02682e4a7f59d7cda1dba
```

```
Key [15]:a13d7141ef1f6c7d867e3d175467381b
Key [16]:08b2bc058e50d6141cdd566a307e1acc
Key [17]:057b2b4b4be5dc0ac49e50489b8006c9
round  1:5cfacc773bae995cd7f1b81e7c9ec7df
Key [ 1]:1e717950f5828f3930fe4a9395858815
Key [ 2]:d1623369b733d98bbc894f75866c544c
round  2:d571ffa21d9daa797b1a0a3c962fc64c
Key [ 3]:4abf27664ae364cc8a7e5bcf88214cc4
Key [ 4]:2aaedda8dc4933dd6aeaf6e5c0d5a482
round  3:e17c8e498a00f125bf654c938c23f36d
added ->:bd765a3eb1ae8a796856048df0c1bab2
Key [ 5]:bc7f8ab2d86000f47b1946cc8d7a7a2b
Key [ 6]:6b28544cb13ec6c5d98470df2cf900b7
round  4:a9727c26f2f06bd9920e83c8605dcd76
Key [ 7]:1be840d9107f2c9523f66bb19f5464a1
Key [ 8]:61d6fb1aa2f0c2b26fb2a3d6de8c177c
round  5:aeff751f146eab7e4626b2e2c9e2fb39
Key [ 9]:adabfc82570c568a233173099f23f4c2
Key [10]:b7df6b55ad266c0f1ff7452101f59101
round  6:cf412b95f454d5185e67ca671892e5bd
Key [11]:8e04a7282a2950dcbaea28f300e22de3
Key [12]:21362c114433e29bda3e4d51f803b0cf
round  7:16165722fe4e07ef88f8056b17d89567
Key [13]:710c8fd5bb3cbb5f132a7061de518bd9
Key [14]:0791de7334f4c87285809343f3ead3bd
round  8:28854cd6ad4a3c572b15490d4b81bc3f
Key [15]:4f47f0e5629a674bfcd13770eb3a3bd9
Key [16]:58a6d9a16a284cc0aead2126c79608a1
Key [17]:a564082a0a98399f43f535fd5cefad34
sres    :80e5629c
aco     :a6fe4dcde3924611d3cc6ba1


========================================
```

9.2 FOUR TESTS OF E21

```
rand    :00000000000000000000000000000000
address :000000000000
round  1:00000000000000000000000000000000
Key [ 1]:00000000000000000000000000000006
Key [ 2]:4697b1baa3b7100ac537b3c95a28dc94
round  2:98611307ab76bbde9a86af1ce8cad412
Key [ 3]:ecabaac66795580df89af66e665d863d
Key [ 4]:8ac3d8896ae9364943bfebd4a2a768a0
round  3:820999ad2e6618f4b578974beeedf9e7
added ->:820999ad2e6618f4b578974beeedf9e7
Key [ 5]:5d57921fd5715cbb22c1bedb1c996394
Key [ 6]:2a61b8343219fdfb1740e9541d41448f
round  4:acd6edec87581ac22dbdc64ea4ced3a2
Key [ 7]:dd0480dee731d67f01ba0f39da6f23ca
Key [ 8]:3ad01cd1303e12a18dcfe0a8af82592c
```

```
round  5:1c7798732f09fbfe25795a4a2fbc93c2
Key [ 9]:7dadb2efc287ce7b0c1302904f2e7233
Key [10]:c08dcfa981e2f4572f6c7a9f52e11538
round  6:c05b88b56aa70e9c40c79bb81cd911bd
Key [11]:fc2042c708658a555e8c147660ffdfd7
Key [12]:fa0b21002605a6b9e89e624cd99150d2
round  7:abacc71b481c84c798d1bdf3d62f7e20
Key [13]:18b407e44a5ba4c80ecb48694b4e9c35
Key [14]:454d57e8253c0c4a8b3fcca7db6baef4
round  8:e8204e1183ae85cf19edb2c86215b700
Key [15]:2d0b946d9db52674f29353b0f011ed83
Key [16]:76c316733b1e8e70bd861b477e2456f1
Key [17]:8e4697b1baa3b7100ac537b3c95a28ac
Ka      :d14ca028545ec262cee700e39b5c39ee
----------------------------------------
rand    :2dd9a550343191304013b2d7e1189d09
address :cac4364303b6
round  1:cac4364303b6cac4364303b6cac43643
Key [ 1]:2dd9a550343191304013b2d7e1189d0f
Key [ 2]:14c4335b2c43910c5dcc71d81a14242b
round  2:e169f788aad45a9011f11db5270b1277
Key [ 3]:55bfb712cba168d1a48f6e74cd9f4388
Key [ 4]:2a2b3aacca695caef2821b0fb48cc253
round  3:540f9c76652e92c44987c617035037bf
added ->:9ed3d23566e45c007fcac9a1c9146dfc
Key [ 5]:a06aab22d9a287384042976b4b6b00ee
Key [ 6]:c229d054bb72e8eb230e6dcdb32d16b7
round  4:83659a41675f7171ea57909dc5a79ab4
Key [ 7]:23c4812ab1905ddf77dedaed4105649a
Key [ 8]:40d87e272a7a1554ae2e85e3638cdf52
round  5:0b9382d0ed4f2fccdbb69d0db7b130a4
Key [ 9]:bdc064c6a39f6b84fe40db359f62a3c4
Key [10]:58228db841ce3cee983aa721f36aa1b9
round  6:c6ebda0f8f489792f09c189568226c1f
Key [11]:a815bacd6fa747a0d4f52883ac63ebe7
Key [12]:a9ce513b38ea006c333ecaaefcf1d0f8
round  7:75a8aba07e69c9065bcd831c40115116
Key [13]:3635e074792d4122130e5b824e52cd60
Key [14]:511bdb61bb28de72a5d794bffbf407df
round  8:57a6e279dcb764cf7dd6a749dd60c735
Key [15]:a32f5f21044b6744b6d913b13cdb4c0a
Key [16]:9722bbaeef281496ef8c23a9d41e92f4
Key [17]:807370560ad7e8a13a054a65a03b4049
Ka      :e62f8bac609139b3999aedbc9d228042
----------------------------------------
rand    :dab3cffe9d5739d1b7bf4a667ae5ee24
address :02f8fd4cd661
round  1:02f8fd4cd66102f8fd4cd66102f8fd4c
Key [ 1]:dab3cffe9d5739d1b7bf4a667ae5ee22
Key [ 2]:e315a8a65d809ec7c289e69c899fbdcc
round  2:ef85ff081b8709405e19f3e275cec7dc
Key [ 3]:df6a119bb50945fc8a3394e7216448f3
```

```
Key [ 4]:87fe86fb0d58b5dd0fb3b6b1dab51d07
round  3:aa25c21bf577d92dd97381e3e9edcc54
added ->:a81dbf5723d8dbd524bf5782ebe5c918
Key [ 5]:36cc253c506c0021c91fac9d8c469e90
Key [ 6]:d5fda00f113e303809b7f7d78a1a2b0e
round  4:9e69ce9b53caec3990894d2baed41e0d
Key [ 7]:c14b5edc10cabf16bc2a2ba4a8ae1e40
Key [ 8]:74c6131afc8dce7e11b03b1ea8610c16
round  5:a5460fa8cedca48a14fd02209e01f02e
Key [ 9]:346cfc553c6cbc9713edb55f4dcbc96c
Key [10]:bddf027cb059d58f0509f8963e9bdec6
round  6:92b33f11eadcacc5a43dd05f13d334dd
Key [11]:8eb9e040c36c4c0b4a7fd3dd354d53c4
Key [12]:c6ffecdd5e135b20879b9dfa4b34bf51
round  7:fb0541aa5e5df1a61c51aef606eb5a41
Key [13]:bf12f5a6ba08dfc4fda4bdfc68c997d9
Key [14]:37c4656b9215f3c959ea688fb64ad327
round  8:f0bbd2b94ae374346730581fc77a9c98
Key [15]:e87bb0d86bf421ea4f779a8eee3a866c
Key [16]:faa471e934fd415ae4c0113ec7f0a5ad
Key [17]:95204a80b8400e49db7cf6fd2fd40d9a
Ka      :b0376d0a9b338c2e133c32b69cb816b3
----------------------------------------
rand    :13ecad08ad63c37f8a54dc56e82f4dc1
address :9846c5ead4d9
round  1:9846c5ead4d99846c5ead4d99846c5ea
Key [ 1]:13ecad08ad63c37f8a54dc56e82f4dc7
Key [ 2]:ad04f127bed50b5e671d6510d392eaed
round  2:97374e18cdd0a6f7a5aa49d1ac875c84
Key [ 3]:57ad159e5774fa222f2f3039b9cd5101
Key [ 4]:9a1e9e1068fede02ef90496e25fd8e79
round  3:9dd3260373edd9d5f4e774826b88fd2d
added ->:0519ebe9a7c6719331d1485bf3cec2c7
Key [ 5]:378dce167db62920b0b392f7cfca316e
Key [ 6]:db4277795c87286faee6c9e9a6b71a93
round  4:40ec6563450299ac4e120d88672504d6
Key [ 7]:ec01aa2f5a8a793b36c1bb858d254380
Key [ 8]:2921a66cfa5bf74ac535424564830e98
round  5:57287bbb041bd6a56c2bd931ed410cd4
Key [ 9]:07018e45aab61b3c3726ee3d57dbd5f6
Key [10]:627381f0fa4c02b0c7d3e7dfbffc3333
round  6:66affa66a8dcd36e36bf6c3f1c6a276e
Key [11]:33b57c925bd5551999f716e138efbe79
Key [12]:a6dc7f9aa95bcc9243aebd12608f657a
round  7:450e65184fd8c72c578d5cdecb286743
Key [13]:a6a6db00fd8c72a28ea57ea542f6e102
Key [14]:dcf3377daeb2e24e61f0ad6620951c1f
round  8:e5eb180b519a4e673f21b7c4f4573f3d
Key [15]:621240b9506b462a7fa250da41844626
Key [16]:ae297810f01f43dc35756cd119ee73d6
Key [17]:b959835ec2501ad3894f8b8f1f4257f9
Ka      :5b61e83ad04d23e9d1c698851fa30447
```

==========

9.3 THREE TESTS OF E22

(for K_master and overlay generation)

```
rand    :001de169248850245a5f7cc7f0d6d633
PIN     :d5a51083a04a1971f18649ea8b79311a
round  1:001de169248850245a5f7cc7f0d6d623
Key [ 1]:d5a51083a04a1971f18649ea8b79311a
Key [ 2]:7317cdbff57f9b99f9810a2525b17cc7
round  2:5f05c143347b59acae3cb002db23830f
Key [ 3]:f08bd258adf1d4ae4a54d8ccb26220b2
Key [ 4]:91046cbb4ccc43db18d6dd36ca7313eb
round  3:c8f3e3300541a25b6ac5a80c3105f3c4
added ->:c810c45921c9f27f302424cbc1dbc9e7
Key [ 5]:67fb2336f4d9f069da58d11c82f6bd95
Key [ 6]:4fed702c75bd72c0d3d8f38707134c50
round  4:bd5e0c3a97fa55b91a3bbbf306ebb978
Key [ 7]:41c947f80cdc0464c50aa89070af314c
Key [ 8]:680eecfa8daf41c7109c9a5cb1f26d75
round  5:21c1a762c3cc33e75ce8976a73983087
Key [ 9]:6e33fbd94d00ff8f72e8a7a0d2cebc4c
Key [10]:f4d726054c6b948add99fabb5733ddc3
round  6:56d0df484345582f6b574a449ba155eb
Key [11]:4eda2425546a24cac790f49ef2453b53
Key [12]:cf2213624ed1510408a5a3e00b7333df
round  7:120cf9963fe9ff22993f7fdf9600d9b8
Key [13]:d04b1a25b0b8fec946d5ecfa626d04c9
Key [14]:01e5611b0f0e140bdb64585fd3ae5269
round  8:a6337400ad8cb47fefb91332f5cb2713
Key [15]:f15b2dc433f534f61bf718770a3698b1
Key [16]:f990d0273d8ea2b9e0b45917a781c720
Key [17]:f41b3cc13d4301297bb6bdfcb3e5a1dd
Ka      :539e4f2732e5ae2de1e0401f0813bd0d
----------------------------------------
rand    :67ed56bfcf99825f0c6b349369da30ab
PIN     :7885b515e84b1f082cc499976f1725ce
round  1:67ed56bfcf99825f0c6b349369da30bb
Key [ 1]:7885b515e84b1f082cc499976f1725ce
Key [ 2]:72445901fdaf506beb036f4412512248
round  2:6b160b66a1f6c26c1f3432f463ef5aa1
Key [ 3]:59f0e4982e97633e5e7fd133af8f2c5b
Key [ 4]:b4946ec77a41bf7c729d191e33d458ab
round  3:3f22046c964c3e5ca2a26ec9a76a9f67
added ->:580f5ad359e5c003ae0da25ace44cfdc
Key [ 5]:eb0b839f97bdf534183210678520bbef
Key [ 6]:cff0bc4a94e5c8b2a2d24d9f59031e19
round  4:87aa61fc0ff88e744c195249b9a33632
Key [ 7]:592430f14d8f93db95dd691af045776d
Key [ 8]:3b55b404222bf445a6a2ef5865247695
round  5:83dcf592a854226c4dcd94e1ecf1bc75
```

```
Key [ 9]:a9714b86319ef343a28b87456416bd52
Key [10]:e6598b24390b3a0bf2982747993b0d78
round  6:dee0d13a52e96bcf7c72045a21609fc6
Key [11]:62051d8c51973073bff959b032c6e1e2
Key [12]:29e94f4ab73296c453c833e217a1a85b
round  7:08488005761e6c7c4dbb203ae453fe3a
Key [13]:0e255970b3e2fc235f59fc5acb10e8ce
Key [14]:d0dfbb3361fee6d4ffe45babf1cd7abf
round  8:0d81e89bddde7a7065316c47574feb8f
Key [15]:c12eee4eb38b7a171f0f736003774b40
Key [16]:8f962523f1c0abd9a087a0dfb11643d3
Key [17]:24be1c66cf8b022f12f1fb4c60c93fd1
Ka      :04435771e03a9daceb8bb1a493ee9bd8
----------------------------------------
rand    :40a94509238664f244ff8e3d13b119d3
PIN     :1ce44839badde30396d03c4c36f23006
round  1:40a94509238664f244ff8e3d13b119c3
Key [ 1]:1ce44839badde30396d03c4c36f23006
Key [ 2]:6dd97a8f91d628be4b18157af1a9dcba
round  2:0eac5288057d9947a24eabc1744c4582
Key [ 3]:fef9583d5f55fd4107ad832a725db744
Key [ 4]:fc3893507016d7c1db2bd034a230a069
round  3:60b424f1082b0cc3bd61be7b4c0155f0
added ->:205d69f82bb17031f9604c465fb26e33
Key [ 5]:0834d04f3e7e1f7f85f0c1db685ab118
Key [ 6]:1852397f9a3723169058e9b62bb3682b
round  4:2c6b65a49d66af6566675afdd6fa7d7d
Key [ 7]:6c10da21d762ae4ac1ba22a96d9007b4
Key [ 8]:9aa23658b90470a78d686344b8a9b0e7
round  5:a2c537899665113a42f1ac24773bdc31
Key [ 9]:137dee3bf879fe7bd02fe6d888e84f16
Key [10]:466e315a1863f47d0f93bc6827cf3450
round  6:e26982980d79b21ed3e20f8c3e71ba96
Key [11]:0b33cf831465bb5c979e6224d7f79f7c
Key [12]:92770660268ede827810d707a0977d73
round  7:e7b063c4e2e3110b89b7e1631c762dd5
Key [13]:7be30ae4961cf24ca17625a77bb7a9f8
Key [14]:be65574a33ae30e6e82dbd2826d3cc1a
round  8:7a963e37b2c2e76b489cfe40a2cf00e5
Key [15]:ed0ba7dd30d60a5e69225f0a33011e5b
Key [16]:765c990f4445e52b39e6ed6105ad1c4f
Key [17]:52627bf9f35d94f30d5b07ef15901adc
Ka      :9cde4b60f9b5861ed9df80858bac6f7f


========================================
```

9.4 TESTS OF E22 WITH PIN AUGMENTING

for PIN lengths 1,...,16 bytes

```
rand    :24b101fd56117d42c0545a4247357048
PIN length =16 octets
PIN     :fd397c7f5c1f937cdf82d8816cc377e2
round  1:24b101fd56117d42c0545a4247357058
Key [ 1]:fd397c7f5c1f937cdf82d8816cc377e2
Key [ 2]:0f7aac9c9b53f308d9fdbf2c78e3c30e
round  2:838edfe1226266953ccba8379d873107
Key [ 3]:0b8ac18d4bb44fad2efa115e43945abc
Key [ 4]:887b16b062a83bfa469772c25b456312
round  3:8cd0c9283120aba89a7f9d635dd4fe3f
added ->:a881cad5673128ea5ad3f7211a096e67
Key [ 5]:2248cbe6d299e9d3e8fd35a91178f65b
Key [ 6]:b92af6237385bd31f8fb57fb1bdd824e
round  4:2648d9c618a622b10ef80c4dbaf68b99
Key [ 7]:2bf5ffe84a37878ede2d4c30be60203b
Key [ 8]:c9cb6cec60cb8a8f29b99fcf3e71e40f
round  5:b5a7d9e96f68b14ccebf361de3914d0f
Key [ 9]:5c2f8a702e4a45575b103b0cce8a91c6
Key [10]:d453db0c9f9ddbd11e355d9a34d9b11b
round  6:632a091e7eefe1336857ddafd1ff3265
Key [11]:32805db7e59c5ed4acabf38d27e3fece
Key [12]:fde3a8eedfa3a12be09c1a8a00890fd7
round  7:048531e9fd3efa95910540150f8b137b
Key [13]:def07eb23f3a378f059039a2124bc4c2
Key [14]:2608c58f23d84a09b9ce95e5caac1ab4
round  8:461814ec7439d412d0732f0a6f799a6a
Key [15]:0a7ed16481a623e56ee1442ffa74f334
Key [16]:12add59aca0d19532f1516979954e369
Key [17]:dd43d02d39ffd6a386a4b98b4ac6eb23
Ka      :a5f2adf328e4e6a2b42f19c8b74ba884
----------------------------------------
rand    :321964061ac49a436f9fb9824ac63f8b
PIN length =15 octets
PIN     :ad955d58b6b8857820ac1262d617a6
address :0314c0642543
round  1:321964061ac49a436f9fb9824ac63f9b
Key [ 1]:ad955d58b6b8857820ac1262d617a603
Key [ 2]:f281736f68e3d30b2ac7c67f125dc416
round  2:7c4a4ece1398681f4bafd309328b7770
Key [ 3]:43c157f4c8b360387c32ab330f9c9aa8
Key [ 4]:3a3049945a298f6d076c19219c47c3cb
round  3:9672b00738bdfaf9bd92a855bc6f3afb
added ->:a48b1401228194bad23161d7f6357960
Key [ 5]:c8e2eaa6d73b7de18f3228ab2173bc69
Key [ 6]:8623f44488222e66a293677cf30bf2bb
round  4:9b30247aad3bf133712d034b46d21c68
Key [ 7]:f3e500902fba31db9bae50ef30e484a4
Key [ 8]:49d4b1137c18f4752dd9955a5a8d2f43
```

```
round  5:4492c25fda08083a768b4b5588966b23
Key [ 9]:9d59c451989e74785cc097eda7e42ab8
Key [10]:251de25f3917dcd99c18646107a641fb
round  6:21ae346635714d2623041f269978c0ee
Key [11]:80b8f78cb1a49ec0c3e32a238e60fddf
Key [12]:beb84f4d20a501e4a24ecfbde481902b
round  7:9b56a3d0f8932f20c6a77a229514fb00
Key [13]:852571b44f35fd9d9336d3c1d2506656
Key [14]:d0a0d510fb06ba76e69b8ee3ebc1b725
round  8:6cd8492b2fd31a86978bcdf644eb08a8
Key [15]:c7ffd523f32a874ed4a93430a25976de
Key [16]:16cdcb25e62964876d951fdcc07030d3
Key [17]:def32c0e12596f9582e5e3c52b303f52
Ka      :c0ec1a5694e2b48d54297911e6c98b8f
----------------------------------------
rand    :d4ae20c80094547d7051931b5cc2a8d6
PIN length =14 octets
PIN     :e1232e2c5f3b833b3309088a87b6
address :fabecc58e609
round  1:d4ae20c80094547d7051931b5cc2a8c6
Key [ 1]:e1232e2c5f3b833b3309088a87b6fabe
Key [ 2]:5f0812b47cd3e9a30d7707050fffa1f2
round  2:1f45f16be89794bef33e4547c9c0916a
Key [ 3]:77b681944763244ffa3cd71b248b79b5
Key [ 4]:e2814e90e04f485958ce58c9133e2be6
round  3:b10d2f4ac941035263cee3552d774d2f
added ->:65bb4f82c9d5572f131f764e7139f5e9
Key [ 5]:520acad20801dc639a2c6d66d9b79576
Key [ 6]:c72255cdb61d42be72bd45390dd25ba5
round  4:ead4dc34207b6ea721c62166e155aaad
Key [ 7]:ebf04c02075bf459ec9c3ec06627d347
Key [ 8]:a1363dd2812ee800a4491c0c74074493
round  5:f507944f3018e20586d81d7f326aae9d
Key [ 9]:b0b6ba79493dc833d7f425be7b8dadb6
Key [10]:08cd23e536b9b9b53e85eb004cba3111
round  6:fff450f4302a2b3571e8405e148346da
Key [11]:fec22374c6937dcd26171f4d2edfada3
Key [12]:0f1a8ef5979c69ff44f620c2e007b6e4
round  7:de558779589897f3402a90ee78c3f921
Key [13]:901fb66f0779d6aad0c0fba1fe812cb5
Key [14]:a0cab3cd15cd23603adc8d4474efb239
round  8:b2df0aa0c9f07fbbaa02f510a29cf540
Key [15]:18edc3f4296dd6f1dea13f7c143117a1
Key [16]:8d3d52d700a379d72ded81687f7546c7
Key [17]:5927badfe602f29345f840bb53e1dea6
Ka      :d7b39be13e3692c65b4a9e17a9c55e17
----------------------------------------
rand    :272b73a2e40db52a6a61c6520549794a
PIN length =13 octets
PIN     :549f2694f353f5145772d8ae1e
address :20487681eb9f
round  1:272b73a2e40db52a6a61c6520549795a
```

```
Key [ 1]:549f2694f353f5145772d8ae1e204876
Key [ 2]:42c855593d66b0c458fd28b95b6a5fbf
round  2:d7276dc8073f7677c31f855bde9501e2
Key [ 3]:75d0a69ae49a2da92e457d767879df52
Key [ 4]:b3aa7e7492971afaa0fb2b64827110df
round  3:71aae503831133d19bc452da4d0e409b
added ->:56d558a1671ee8fbf12518884857b9c1
Key [ 5]:9c8cf1604a98e9a503c342e272de5cf6
Key [ 6]:d35bc2df6b85540a27642106471057d9
round  4:f41a709c89ea80481aa3d2b9b2a9f8ca
Key [ 7]:b454dda74aeb4eff227ba48a58077599
Key [ 8]:bcba6aec050116aa9b7c6a9b7314d796
round  5:20fdda20f4a26b1bd38eb7f355a7be87
Key [ 9]:d41f8a9de0a716eb7167a1b6e321c528
Key [10]:5353449982247782d168ab43f17bc4d8
round  6:a70e316997eeed49a5a9ef9ba5e913b5
Key [11]:32cbc9cf1a81e36a45153972347ce4ac
Key [12]:5747619006cf4ef834c749f2c4b9feb6
round  7:e66f2317a825f589f76b47b6aa6e73fb
Key [13]:f9b68beba0a09d2a570a7dc88cc3c3c2
Key [14]:55718f9a4f0b1f9484e8c6b186a41a4b
round  8:5f68f940440a9798e074776019804ada
Key [15]:4ecc29be1b4d78433f6aa30db974a7fb
Key [16]:8470a066ffb00cda7b08059599f919f5
Key [17]:f39a36d74e960a051e1ca98b777848f4
Ka      :9ac64309a37c25c3b4a584fc002a1618
----------------------------------------
rand    :7edb65f01a2f45a2bc9b24fb3390667e
PIN length =12 octets
PIN     :2e5a42797958557b23447ca8
address :04f0d2737f02
round  1:7edb65f01a2f45a2bc9b24fb3390666e
Key [ 1]:2e5a42797958557b23447ca804f0d273
Key [ 2]:18a97c856561eb23e71af8e9e1be4799
round  2:3436e12db8ffdc1265cb5a86da2fed0b
Key [ 3]:7c0908dcbc73201e17c4f7aa1ab8aec8
Key [ 4]:7cb58833602fbe4194c7cc797ce8c454
round  3:caed6af4226f67e4ad1914620803ef2a
added ->:b4c8cf04389eac4611b438993b935544
Key [ 5]:f4dce7d607b5234562d0ebb2267b08b8
Key [ 6]:560b75c5545751fd8fa99fa4346e654b
round  4:ee67c87d6f74bb75db98f68bff0192c1
Key [ 7]:32f10cefd8d3e6424c6f91f1437808af
Key [ 8]:a934a46045be30fb3be3a5f3f7b18837
round  5:792398dcbeb8d10bdb07ae3c819e943c
Key [ 9]:a0f12e97c677a0e8ac415cd2c8a7ca88
Key [10]:e27014c908785f5ca03e8c6a1da3bf13
round  6:e778b6e0c3e8e7edf90861c7916d97a8
Key [11]:1b4a4303bcc0b2e0f41c72d47654bd9f
Key [12]:4b1302a50046026d6c9054fc8387965a
round  7:1fafddc7efa5f04c1dec1869d3f2d9bb
Key [13]:58c334bb543d49eca562cdbe0280e0fc
```

```
Key [14]:bdb60d383c692d06476b76646c8dec48
round  8:3d7c326d074bd6aa222ea050f04a3c7f
Key [15]:78c0162506be0b5953e8403c01028f93
Key [16]:24d7dbbe834dbd7b67f57fcf0d39d60f
Key [17]:2e74f1f3331c0f6585e87b2f715e187e
Ka      :d3af4c81e3f482f062999dee7882a73b
----------------------------------------
rand    :26a92358294dce97b1d79ec32a67e81a
PIN length =11 octets
PIN     :05fbad03f52fa9324f7732
address :b9ac071f9d70
round  1:26a92358294dce97b1d79ec32a67e80a
Key [ 1]:05fbad03f52fa9324f7732b9ac071f9d
Key [ 2]:2504c9691c04a18480c8802e922098c0
round  2:0be20e3d76888e57b6bf77f97a8714fb
Key [ 3]:576b2791d1212bea8408212f2d43e77e
Key [ 4]:90ae36dcce8724adb618f912d1b27297
round  3:19696670607644532 57d906b7e58bd5b
added ->:3f12892849c312c494542ea854bfa551
Key [ 5]:bc492c42c9e87f56ec31af5474e9226e
Key [ 6]:c135d1dbed32d9519acfb4169f3e1a10
round  4:ac404205118fe771e54aa6f392da1153
Key [ 7]:83ccbdbbaf17889b7d18254dc9252fa1
Key [ 8]:80b90a1767d3f2848080802764e21711
round  5:41795e89ae9a0cf776ffece76f47fd7a
Key [ 9]:cc24e4a86e8eed129118fd3d5223a1dc
Key [10]:7b1e9c0eb9dab083574be7b7015a62c9
round  6:29ca9e2f87ca00370ef1633505bfba4b
Key [11]:888e6d88cf4beb965cf7d4f32b696baa
Key [12]:6d642f3e5510b0b043a44daa2cf5eec0
round  7:81fc891c3c6fd99acc00028a387e2366
Key [13]:e224f85da2ab63a23e2a3a036e421358
Key [14]:c8dc22aaa739e2cb85d6a0c08226c7d0
round  8:e30b537e7a000e3d2424a9c0f04c4042
Key [15]:a969aa818c6b324bae391bedcdd9d335
Key [16]:6974b6f2f07e4c55f2cc0435c45bebd1
Key [17]:134b925ebd98e6b93c14aee582062fcb
Ka      :be87b44d079d45a08a71d15208c5cb50
----------------------------------------
rand    :0edef05327eab5262430f21fc91ce682
PIN length =10 octets
PIN     :8210e47390f3f48c32b3
address :7a3cdfe377d1
round  1:0edef05327eab5262430f21fc91ce692
Key [ 1]:8210e47390f3f48c32b37a3cdfe377d1
Key [ 2]:c6be4c3e425e749b620a94c779e33a7e
round  2:07ca3c7a7a6bcbc31d79a856d9cffc0e
Key [ 3]:2587cec2a4b8e4f996a9ed664350d5dd
Key [ 4]:70e4bf72834d9d3dbb7eb2c239216dc0
round  3:792ad2ac4e4559d1463714d2f161b6f4
added ->:7708c2ff692f0ef7626706cd387d9c66
Key [ 5]:6696e1e7f8ac037e1fff3598f0c164e2
```

```
Key [ 6]:23dbfe4d0b561bea08fbcef25e49b648
round  4:7d8c71a9d7fbdcbd851bdf074550b100
Key [ 7]:b03648acd021550edee904431a02f00c
Key [ 8]:cb169220b7398e8f077730aa4bf06baa
round  5:b6fcaa45064ffd557e4b7b30cfbb83e0
Key [ 9]:af602c2ba16a454649951274c2be6527
Key [10]:5d60b0a7a09d524143eca13ad680bc9c
round  6:b3416d391a0c26c558843debd0601e9e
Key [11]:9a2f39bfe558d9f562c5f09a5c3c0263
Key [12]:72cae8eebd7fabd9b1848333c2aab439
round  7:abe4b498d9c36ea97b8fd27d7f813913
Key [13]:15f27ea11e83a51645d487b81371d7dc
Key [14]:36083c8666447e03d33846edf444eb12
round  8:8032104338a945ba044d102eabda3b22
Key [15]:0a3a8977dd48f3b6c1668578befadd02
Key [16]:f06b6675d78ca0ee5b1761bdcdab516d
Key [17]:cbc8a7952d33aa0496f7ea2d05390b23
Ka      :bf0706d76ec3b11cce724b311bf71ff5
----------------------------------------
rand    :86290e2892f278ff6c3fb917b020576a
PIN length = 9 octets
PIN     :3dcdffcfd086802107
address :791a6a2c5cc3
round  1:86290e2892f278ff6c3fb917b0205765
Key [ 1]:3dcdffcfd0868021077791a6a2c5cc33d
Key [ 2]:b4962f40d7bb19429007062a3c469521
round  2:1ec59ffd3065f19991872a7863b0ef02
Key [ 3]:eb9ede6787dd196b7e340185562bf28c
Key [ 4]:2964e58aacf7287d1717a35b100ae23b
round  3:f817406f1423fc2fe33e25152679eaaf
added ->:7e404e47861574d08f7dde02969941ca
Key [ 5]:6abf9a314508fd61e486fa4e376c3f93
Key [ 6]:6da148b7ee2632114521842cbb274376
round  4:e9c2a8fac22b8c7cf0c619e2b3f890ed
Key [ 7]:df889cc34fda86f01096d52d116e620d
Key [ 8]:5eb04b147dc39d1974058761ae7b73fc
round  5:444a8aac0efee1c02f8d38f8274b7b28
Key [ 9]:8426cc59eee391b2bd50cf8f1efef8b3
Key [10]:8b5d220a6300ade418da791dd8151941
round  6:9185f983db150b1bccab1e5c12eb63a1
Key [11]:82ba4ddef833f6a4d18b07aa011f2798
Key [12]:ce63d98794682054e73d0359dad35ec4
round  7:5eded2668f5916dfd036c09e87902886
Key [13]:da794357652e80c70ad8b0715dbe33d6
Key [14]:732ef2c0c3220b31f3820c375e27bb29
round  8:88a5291b4acbba009a85b7dd6a834b3b
Key [15]:3ce75a61d4b465b70c95d7ccd5799633
Key [16]:5df9bd2c3a17a840cdaafb76c171db7c
Key [17]:3f8364b089733d902bccb0cd3386846f
Ka      :cdb0cc68f6f6fbd70b46652de3ef3ffb
----------------------------------------
rand    :3ab52a65bb3b24a08eb6cd284b4b9d4b
```

```
PIN length = 8 octets
PIN      :d0fb9b6838d464d8
address :25a868db91ab
round  1:3ab52a65bb3b24a08eb6cd284b4b9d45
Key [ 1]:d0fb9b6838d464d825a868db91abd0fb
Key [ 2]:2573f47b49dad6330a7a9155b7ae8ba1
round  2:ad2ffdff408fcfab44941016a9199251
Key [ 3]:d2c5b8fb80cba13712905a589adaee71
Key [ 4]:5a3381511b338719fae242758dea0997
round  3:2ddc17e570d7931a2b1d13f6ace928a5
added ->:17914180cb12b7baa5d3e0dee734c5e0
Key [ 5]:e0a4d8ac27fbe2783b7bcb3a36a6224d
Key [ 6]:949324c6864deac3eca8e324853e11c3
round  4:62c1db5cf31590d331ec40ad692e8df5
Key [ 7]:6e67148088a01c2d4491957cc9ddc4aa
Key [ 8]:557431deab7087bb4c03fa27228f60c6
round  5:9c8933bc361f4bde4d1bda2b5f8bb235
Key [ 9]:a2551aca53329e70ade3fd2bb7664697
Key [10]:05d0ad35de68a364b54b56e2138738fe
round  6:9156db34136aa06655bf28a05be0596a
Key [11]:1616a6b13ce2f2895c722e8495181520
Key [12]:b12e78a1114847b01f6ed2f5a1429a23
round  7:84dcc292ed836c1c2d523f2a899a2ad5
Key [13]:316e144364686381944e95afd8a026bb
Key [14]:1ab551b88d39d97ea7a9fe136dbfe2e1
round  8:87bdcac878d777877f4eccf042cfee5e
Key [15]:70e21ab08c23c7544524b64492b25cc9
Key [16]:35f730f2ae2b950a49a1bf5c8b9f8866
Key [17]:2f16924c22db8b74e2eadf1ba4ebd37c
Ka       :983218718ca9aa97892e312d86dd9516
-----------------------------------------
rand     :a6dc447ff08d4b366ff96e6cf207e179
PIN length = 7 octets
PIN      :9c57e10b4766cc
address :54ebd9328cb6
round  1:a6dc447ff08d4b366ff96e6cf207e174
Key [ 1]:9c57e10b4766cc54ebd9328cb69c57e1
Key [ 2]:00a609f4d61db26993c8177e3ee2bba8
round  2:1ed26b96a306d7014f4e5c9ee523b73d
Key [ 3]:646d7b5f9aaa528384bda3953b542764
Key [ 4]:a051a42212c0e9ad5c2c248259aca14e
round  3:a53f526db18e3d7d53edbfc9711041ed
added ->:031b9612411b884b3ce62da583172299
Key [ 5]:d1bd5e64930e7f838d8a33994462d8b2
Key [ 6]:5dc7e2291e32435665ebd6956bec3414
round  4:9438be308ec83f35c560e2796f4e0559
Key [ 7]:10552f45af63b0f15e2919ab37f64fe7
Key [ 8]:c44d5717c114a58b09207392ebe341f8
round  5:b79a7b14386066d339f799c40479cb3d
Key [ 9]:6886e47b782325568eaf59715a75d8ff
Key [10]:8e1e335e659cd36b132689f78c147bda
round  6:ef232462228aa166438d10c34e17424b
```

```
Key [11]:8843efeedd5c2b7c3304d647f932f4d1
Key [12]:13785aaedd0adf67abb4f01872392785
round  7:02d133fe40d15f1073673b36bba35abd
Key [13]:837d7ca2722419e6be3fae35900c3958
Key [14]:93f8442973e7fccf2e7232d1d057c73a
round  8:275506a3d08c84e94cc58ed60054505e
Key [15]:8a7a9edffa3c52918bc6a45f57d91f5d
Key [16]:f214a95d777f763c56109882c4b52c84
Key [17]:10e2ee92c5ea1ddc5eb010e55510c403
Ka      :9cd6650ead86323e87cafb1ff516d1e0
----------------------------------------
rand    :3348470a7ea6cc6eb81b40472133262c
PIN length = 6 octets
PIN     :fcad169d7295
address :430d572f8842
round  1:3348470a7ea6cc6eb81b404721332620
Key [ 1]:fcad169d7295430d572f8842fcad169d
Key [ 2]:b3479d4d4fd178c43e7bc5b0c7d8983c
round  2:af976da9225066d563e10ab955e6fc32
Key [ 3]:7112462b37d82dd81a2a35d9eb43cb7c
Key [ 4]:c5a7030f8497945ac7b84600d1d161fb
round  3:d08f826ebd55a0bd7591c19a89ed9bde
added ->:e3d7c964c3fb6cd3cdac01dda820c1fe
Key [ 5]:84b0c6ef4a63e4dff19b1f546d683df5
Key [ 6]:f4023edfc95d1e79ed4bb4de9b174f5d
round  4:6cd952785630dfc7cf81eea625e42c5c
Key [ 7]:ea38dd9a093ac9355918632c90c79993
Key [ 8]:dbba01e278ddc76380727f5d7135a7de
round  5:93573b2971515495978264b88f330f7f
Key [ 9]:d4dc3a31be34e412210fafa6eca00776
Key [10]:39d1e190ee92b0ff16d92a8be58d2fa0
round  6:b3f01d5e7fe1ce6da7b46d8c389baf47
Key [11]:1eb081328d4bcf94c9117b12c5cf22ac
Key [12]:7e047c2c552f9f1414d946775fabfe30
round  7:0b833bff6106d5bae033b4ce5af5a924
Key [13]:e78e685d9b2a7e29e7f2a19d1bc38ebd
Key [14]:1b582272a3121718c4096d2d8602f215
round  8:23de0bbdc70850a7803f4f10c63b2c0f
Key [15]:8569e860530d9c3d48a0870dac33f676
Key [16]:6966b528fdd1dc222527052c8f6cf5a6
Key [17]:a34244c757154c53171c663b0b56d5c2
Ka      :98f1543ab4d87bd5ef5296fb5e3d3a21
----------------------------------------
rand    :0f5bb150b4371ae4e5785293d22b7b0c
PIN length = 5 octets
PIN     :b10d068bca
address :b44775199f29
round  1:0f5bb150b4371ae4e5785293d22b7b07
Key [ 1]:b10d068bcab44775199f29b10d068bca
Key [ 2]:aec70d1048f1bbd2c18040318a8402ad
round  2:342d2b79d7fb7cd110379742b9842c79
Key [ 3]:6d8d5cf338f29ef4420639ef488e4fa9
```

```
Key [ 4]:a1584117541b759ba6d9f7eb2bedcbba
round  3:9407e8e3e810603921bf81cfda62770a
added ->:9b6299b35c477addc437d35c088df20d
Key [ 5]:09a20676666aeed6f22176274eb433f4
Key [ 6]:840472c001add5811a054be5f5c74754
round  4:9a3ba953225a7862c0a842ed3d0b2679
Key [ 7]:fad9e45c8bf70a972fcd9bff0e8751f5
Key [ 8]:e8f30ff666dfd212263416496ff3b2c2
round  5:2c573b6480852e875df34b28a5c44509
Key [ 9]:964cdba0cf8d593f2fc40f96daf8267a
Key [10]:bcd65c11b13e1a70bcd4aafba8864fe3
round  6:21b0cc49e880c5811d24dee0194e6e9e
Key [11]:468c8548ea9653c1a10df6288dd03c1d
Key [12]:5d252d17af4b09d3f4b5f7b5677b8211
round  7:e6d6bdcd63e1d37d9883543ba86392fd
Key [13]:e814bf307c767428c67793dda2df95c7
Key [14]:4812b979fdc20f0ff0996f61673a42cc
round  8:e3dde7ce6bd7d8a34599aa04d6a760ab
Key [15]:5b1e2033d1cd549fc4b028146eb5b3b7
Key [16]:0f284c14fb8fe706a5343e3aa35af7b1
Key [17]:b1f7a4b7456d6b577fded6dc7a672e37
Ka      :c55070b72bc982adb972ed05d1a74ddb
----------------------------------------
rand    :148662a4baa73cfadb55489159e476e1
PIN length = 4 octets
PIN     :fb20f177
address :a683bd0b1896
round  1:148662a4baa73cfadb55489159e476eb
Key [ 1]:fb20f177a683bd0b1896fb20f177a683
Key [ 2]:47266cefbfa468ca7916b458155dc825
round  2:3a942eb6271c3f4e433838a5d3fcbd27
Key [ 3]:688853a6d6575eb2f6a2724b0fbc133b
Key [ 4]:7810df048019634083a2d9219d0b5fe0
round  3:9c835b98a063701c0887943596780769
added ->:8809bd3c1a0aace6d3dcdca4cf5c7d82
Key [ 5]:c78f6dcf56da1bbd413828b33f5865b3
Key [ 6]:eb3f3d407d160df3d293a76d1a513c4a
round  4:7e68c4bafa020a4a59b5a1968105bab5
Key [ 7]:d330e038d6b19d5c9bb0d7285a360064
Key [ 8]:9bd3ee50347c00753d165faced702d9c
round  5:227bad0cf0838bdb15b3b3872c24f592
Key [ 9]:9543ad0fb3fe74f83e0e2281c6d4f5f0
Key [10]:746cd0383c17e0e80e6d095a87fd0290
round  6:e026e98c71121a0cb739ef6f59e14d26
Key [11]:fa28bea4b1c417536608f11f406ea1dd
Key [12]:3aee0f4d21699df9cb8caf5354a780ff
round  7:cd6a6d8137d55140046f8991da1fa40a
Key [13]:372b71bc6d1aa6e785358044fbcf05f4
Key [14]:00a01501224c0405de00aa2ce7b6ab04
round  8:52cd7257fe8d0c782c259bcb6c9f5942
Key [15]:c7015c5c1d7c030e00897f104a006d4a
Key [16]:260a9577790c62e074e71e19fd2894df
```

```
Key [17]:c041b7a231493acd15ddcdaee94b9f52
Ka      :7ec864df2f1637c7e81f2319ae8f4671
----------------------------------------
rand    :193a1b84376c88882c8d3b4ee93ba8d5
PIN length = 3 octets
PIN     :a123b9
address :4459a44610f6
round  1:193a1b84376c88882c8d3b4ee93ba8dc
Key [ 1]:a123b94459a44610f6a123b94459a446
Key [ 2]:5f64d384c8e990c1d25080eb244dde9b
round  2:3badbd58f100831d781ddd3ccedefd3f
Key [ 3]:5abc00eff8991575c00807c48f6dbea5
Key [ 4]:127521158ad6798fb6479d1d2268abe6
round  3:0b53075a49c6bf2df2421c655fdedf68
added ->:128d22de7e3247a5decf572bb61987b4
Key [ 5]:f2a1f620448b8e56665608df2ab3952f
Key [ 6]:7c84c0af02aad91dc39209c4edd220b1
round  4:793f4484fb592e7a78756fd4662f990d
Key [ 7]:f6445b647317e7e493bb92bf6655342f
Key [ 8]:3cae503567c63d3595eb140ce60a84c0
round  5:9e46a8df925916a342f299a8306220a0
Key [ 9]:734ed5a806e072bbecb4254993871679
Key [10]:cda69ccb4b07f65e3c8547c11c0647b8
round  6:6bf9cd82c9e1be13fc58eae0b936c75a
Key [11]:c48e531d3175c2bd26fa25cc8990e394
Key [12]:6d93d349a6c6e9ff5b26149565b13d15
round  7:e96a9871471240f198811d4b8311e9a6
Key [13]:5c4951e85875d663526092cd4cbdb667
Key [14]:f19f7758f5cde86c3791efaf563b3fd0
round  8:e94ca67d3721d5fb08ec069191801a46
Key [15]:bf0c17f3299b37d984ac938b769dd394
Key [16]:7edf4ad772a6b9048588f97be25bde1c
Key [17]:6ee7ba6afefc5b561abbd8d6829e8150
Ka      :ac0daabf17732f632e34ef193658bf5d
----------------------------------------
rand    :1453db4d057654e8eb62d7d62ec3608c
PIN length = 2 octets
PIN     :3eaf
address :411fbbb51d1e
round  1:1453db4d057654e8eb62d7d62ec36084
Key [ 1]:3eaf411fbbb51d1e3eaf411fbbb51d1e
Key [ 2]:c3a1a997509f00fb4241aba607109c64
round  2:0b78276c1ebc65707d38c9c5fa1372bd
Key [ 3]:3c729833ae1ce7f84861e4dbad6305cc
Key [ 4]:c83a43c3a66595cb8136560ed29be4ff
round  3:23f3f0f6441563d4c202cee0e5cb2335
added ->:3746cbbb418bb73c2964a536cb8e83b1
Key [ 5]:18b26300b86b70acdd1c8f5cbc7c5da8
Key [ 6]:04efc75309b98cd8f1cef5513c18e41e
round  4:c61afa90d3c14bdf588320e857afdc00
Key [ 7]:517c789cecadc455751af73198749fb8
Key [ 8]:fd9711f913b5c844900fa79dd765d0e2
```

```
round  5:a8a0e02ceb556af8bfa3217898011 83a
Key [ 9]:bb5cf30e7d3ceb930651b1d16ee92750
Key [10]:3d97c7862ecab42720e984972f8efd28
round  6:0b58e922438d224db34b68fca9a5ea12
Key [11]:4ce730344f6b09e449dcdb64cd466666
Key [12]:38828c3a56f922186adcd9b713cdcc31
round  7:b90664c4ac29a8b4bb26debec9ffc5f2
Key [13]:d30fd865ea3e9edcff86a33a2c319649
Key [14]:1fdb63e54413acd968195ab6fa424e83
round  8:6934de3067817cefd811abc5736c163b
Key [15]:a16b7c655bbaa262c807cba8ae166971
Key [16]:7903dd68630105266049e23ca607cda7
Key [17]:888446f2d95e6c2d2803e6f4e815ddc9
Ka      :1674f9dc2063cc2b83d3ef8ba692ebef
----------------------------------------
rand    :1313f7115a9db842fcedc4b10088b48d
PIN length = 1 octets
PIN     :6d
address :008aa9be62d5
round  1:1313f7115a9db842fcedc4b10088b48a
Key [ 1]:6d008aa9be62d56d008aa9be62d56d00
Key [ 2]:46ebfeafb6657b0a1984a8dc0893accf
round  2:839b23b83b5701ab095bafd162ec0ac7
Key [ 3]:8e15595edcf058af62498ee3c1dc6098
Key [ 4]:dd409c3444e94b9cc08396ae967542a0
round  3:c0a2010cc44f2139427f093f4f97ae68
added ->:d3b5f81d9eecd97bbe6ccd8e4f1f62e2
Key [ 5]:487deff5d519f6a6481e947b926f633c
Key [ 6]:5b4b6e3477ed5c2c01f6e607d3418963
round  4:1a5517a0efad3575931d8ea3bee8bd07
Key [ 7]:34b980088d2b5fd6b6a2aceeda99c9c4
Key [ 8]:e7d06d06078acc4ecdbc8da800b73078
round  5:d3ce1fdfe716d72c1075ff37a8a2093f
Key [ 9]:7d375bad245c3b757380021af8ecd408
Key [10]:14dac4bc2f4dc4929a6cceec47f4c3a3
round  6:47e90cb55be6e8dd0f583623c2f2257b
Key [11]:66cfda3c63e464b05e2e7e25f8743ad7
Key [12]:77cfccda1ad380b9fdf1df10846b50e7
round  7:f866ae6624f7abd4a4f5bd24b04b6d43
Key [13]:3e11dd84c031a470a8b66ec6214e44cf
Key [14]:2f03549bdb3c511eea70b65ddbb08253
round  8:02e8e17cf8be4837c9c40706b613dfa8
Key [15]:e2f331229ddfcc6e7bea08b01ab7e70c
Key [16]:b6b0c3738c5365bc77331b98b3fba2ab
Key [17]:f5b3973b636119e577c5c15c87bcfd19
Ka      :38ec0258134ec3f08461ae5c328968a1

========================================
```

9.5 FOUR TESTS OF E3

```
rand    :00000000000000000000000000000000
aco     :48afcdd4bd40fef76693b113
key     :00000000000000000000000000000000
round  1:00000000000000000000000000000000
Key [ 1]:00000000000000000000000000000000
Key [ 2]:4697b1baa3b7100ac537b3c95a28ac64
round  2:78d19f9307d2476a523ec7a8a026042a
Key [ 3]:ecabaac66795580df89af66e66dc053d
Key [ 4]:8ac3d8896ae9364943bfebd4969b68a0
round  3:600265247668dda0e81c07bbb30ed503
Key [ 5]:5d57921fd5715cbb22c1be7bbc996394
Key [ 6]:2a61b8343219fdfb1740e6511d41448f
round  4:d7552ef7cc9dbde568d80c2215bc4277
Key [ 7]:dd0480dee731d67f01a2f739da6f23ca
Key [ 8]:3ad01cd1303e12a1cd0fe0a8af82592c
round  5:fb06bef32b52ab8f2a4f2b6ef7f6d0cd
Key [ 9]:7dadb2efc287ce75061302904f2e7233
Key [10]:c08dcfa981e2c4272f6c7a9f52e11538
round  6:b46b711ebb3cf69e847a75f0ab884bdd
Key [11]:fc2042c708e409555e8c147660ffdfd7
Key [12]:fa0b21001af9a6b9e89e624cd99150d2
round  7:c585f308ff19404294f06b292e978994
Key [13]:18b40784ea5ba4c80ecb48694b4e9c35
Key [14]:454d54e5253c0c4a8b3fcca7db6baef4
round  8:2665fadb13acf952bf74b4ab12264b9f
Key [15]:2df37c6d9db52674f29353b0f011ed83
Key [16]:b60316733b1e8e70bd861b477e2456f1
Key [17]:884697b1baa3b7100ac537b3c95a28ac
round  1:5d3ecb17f26083df0b7f2b9b29aef87c
Key [ 1]:e9e5dfc1b3a79583e9e5dfc1b3a79583
Key [ 2]:7595bf57e0632c59f435c16697d4c864
round  2:de6fe85c5827233fe22514a16f321bd8
Key [ 3]:e31b96afcc75d286ef0ae257cbbc05b7
Key [ 4]:0d2a27b471bc0108c6263aff9d9b3b6b
round  3:7cd335b50d09d139ea6702623af85edb
added ->:211100a2ff6954e6e1e62df913a656a7
Key [ 5]:98d1eb5773cf59d75d3b17b3bc37c191
Key [ 6]:fd2b79282408ddd4ea0aa7511133336f
round  4:991dccb3201b5b1c4ceff65a3711e1e9
Key [ 7]:331227756638a41d57b0f7e071ee2a98
Key [ 8]:aa0dd8cc68b406533d0f1d64aabacf20
round  5:18768c7964818805fe4c6ecae8a38599
Key [ 9]:669291b0752e63f806fce76f10e119c8
Key [10]:ef8bdd46be8ee0277e9b78adef1ec154
round  6:82f9aa127a72632af43d1a17e7bd3a09
Key [11]:f3902eb06dc409cfd78384624964bf51
Key [12]:7d72702b21f97984a721c99b0498239d
round  7:1543d7870bf2d6d6efab3cbf62dca97d
Key [13]:532e60bceaf902c52a06c2c283ecfa32
Key [14]:181715e5192efb2a64129668cf5d9dd4
```

```
round  8:eee3e8744a5f8896de95831ed837ffd5
Key [15]:83017c1434342d4290e961578790f451
Key [16]:2603532f365604646ff65803795ccce5
Key [17]:882f7c907b565ea58dae1c928a0dcf41
kc      :cc802aecc7312285912e90af6a1e1154
----------------------------------------
rand    :950e604e655ea3800fe3eb4a28918087
aco     :68f4f472b5586ac5850f5f74
key     :34e86915d20c485090a6977931f96df5
round  1:950e604e655ea3800fe3eb4a28918087
Key [ 1]:34e86915d20c485090a6977931f96df5
Key [ 2]:8de2595003f9928efaf37e5229935bdb
round  2:d46f5a04c967f55840f83d1cdb5f9afc
Key [ 3]:46f05ec979a97cb6ddf842ecc159c04a
Key [ 4]:b468f0190a0a83783521deae8178d071
round  3:e16ededе9cb6297f32e1203e442ac73a
Key [ 5]:8a171624dedbd552356094daaadcf12a
Key [ 6]:3085e07c85e4b99313f6e0c837b5f819
round  4:805144e55e1ece96683d23366fc7d24b
Key [ 7]:fe45c27845169a66b679b2097d147715
Key [ 8]:44e2f0c35f64514e8bec66c5dc24b3ad
round  5:edbaf77af070bd22e9304398471042f1
Key [ 9]:0d534968f3803b6af447eaf964007e7b
Key [10]:f5499a32504d739ed0b3c547e84157ba
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Key [14]:41034e5c3fb0c0d4f445f0cf23be79b0
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round  2:6436ddbabe92655c87a7d0c12ae5e5f6
Key [ 3]:fee00bb0de89b6ef0a289696a4faa884
Key [ 4]:33ce2f4411db4dd9b7c42cc586b8a2ba
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kc      :c1beafea6e747e304cf0bd7734b0a9e2
----------------------------------------
rand    :6a8ebcf5e6e471505be68d5eb8a3200c
aco     :658d791a9554b77c0b2f7b9f
key     :35cf77b333c294671d426fa79993a133
round  1:6a8ebcf5e6e471505be68d5eb8a3200c
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Key [ 2]:c4524e53b95b4bf2d7b2f095f63545fd
round  2:ade94ec585db0d27e17474b58192c87a
Key [ 3]:c99776768c6e9f9dd3835c52cea8d18a
Key [ 4]:f1295db23823ba2792f21217fc01d23f
round  3:da8dc1a10241ef9e6e069267cd2c6825
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round  4:e6665ca0772ceecbc21222ff7be074f8
Key [ 7]:2fa1f4e7a4cf3ccd876ec30d194cf196
Key [ 8]:267364be247184d5337586a19df8bf84
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round  4:d4e000be5de78c0f56ff218f3c1df61b
Key [ 7]:8197537aa9d27e67d17c16b182c8ec65
Key [ 8]:d66e00e73d835927a307a3ed79d035d8
round  5:9a4603bdef954cfaade2052604bed4e4
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Key [10]:f91212fa528379651fbd2c32890c5e5f
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Key [11]:283acc551591fadce821b02fb9491814
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kc      :a3032b4df1cceba8adc1a04427224299
----------------------------------------
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aco     :63f701c7013238bbf88714ee
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Key [ 2]:15f74bbbde4b9d1e08f858721f131669
round  2:72abb85fc80c15ec2b00d72873ef9ad4
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Key [ 4]:3003a6aecdee06b9ac295cce30dcdb93
round  3:2f10bab93a0f73742183c68f712dfa24
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Key [ 6]:ddaa90756635579573fe8ca1f93d4a38
round  4:183b145312fd99d5ad08e7ca4a52f04e
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Key [ 8]:702029d8c6e42950762317e730ec5d18
round  5:cbad52d3a026b2e38b9ae6fefffecc32
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Key [10]:034e745246cd2e2cfc3bda39531ca9c5
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Key [11]:0a4d8ff5673731c3dc8fe87e39a34b77
Key [12]:637592fab43a19ac0044a21afef455a2
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Key [13]:6b3fde58f4f6438843cdbe92667622b8
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round  8:f5e12da0e93e26a5850251697ec0b917
Key [15]:2228fe5384e573f48fdd19ba91f1bf57
Key [16]:5f174db2bc88925c0fbc6b5485bafc08
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round  1:0c75eed2b54c1cfb9ff522daef94ed4d
Key [ 1]:a21ceb92d3c027326b4de775865fe8d0
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round  2:48d537ac209a6aa07b70000016c602e8
Key [ 3]:e64f9ef630213260f1f79745a0102ae5
Key [ 4]:af6a59d7cebfd0182dcca9a537c4add8
round  3:8b6d517ac893743a401b3fb7911b64e1
added ->:87e23fa87ddf90c1df10616d7eaf51ac
Key [ 5]:9a6304428b45da128ab64c8805c32452
Key [ 6]:8af4d1e9d80cb73ec6b44e9b6e4f39d8
```

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round  4:9f0512260a2f7a5067efc35bf1706831
Key [ 7]:79cc2d138606f0fca4e549c34a1e6d19
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Key [ 9]:e8fa996448e6b6459ab51e7be101325a
Key [10]:2acc7add7b294acb444cd933f0e74ec9
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Key [12]:e418dfd1bb22ebf1bfc309cd27f5266c
round  7:ee4f7a53849bf73a747065d35f3752b1
Key [13]:80a9959133856586370854db6e0470b3
Key [14]:f4c1bc2f764a0193749f5fc09011a1ae
round  8:8fec6f7249760ebf69e370e9a4b80a92
Key [15]:d036cef70d6470c3f52f1b5d25b0c29d
Key [16]:d0956af6b8700888a1cc88f07ad226dc
Key [17]:1ce8b39c4c7677373c30849a3ee08794
kc      :ea520cfc546b00eb7c3a6cea3ecb39ed

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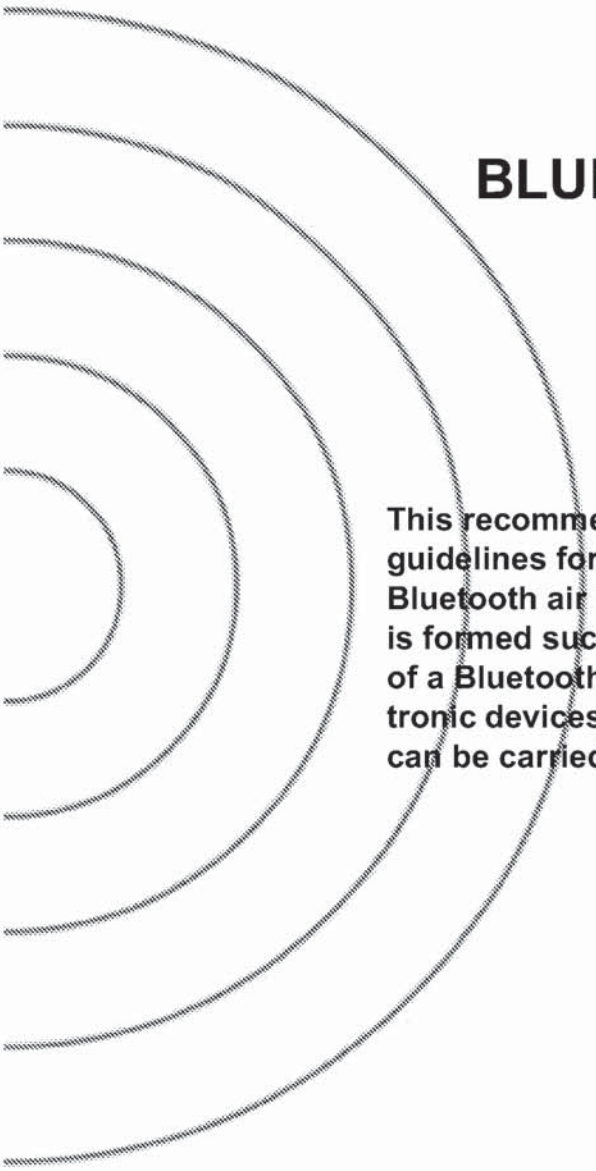
Appendix V



BLUETOOTH AUDIO

This recommendation outlines some general guidelines for voice transmission over the Bluetooth air interface. The recommendation is formed such that a smooth audio interface of a Bluetooth terminal to other audio, electronic devices and cellular terminal equipment can be carried out.

CONTENTS

1 GENERAL AUDIO RECOMMENDATIONS

1.1 MAXIMUM SOUND PRESSURE

It is the sole responsibility of each manufacturer to design their audio products in a safe way with regards to injury to the human ear. Bluetooth doesn't specify maximum sound pressure from an audio device.

1.2 OTHER TELEPHONY NETWORK REQUIREMENTS

It is the sole responsibility of each manufacturer to design the Bluetooth audio product so that it meets the regulatory requirements of all telephony networks that it may be connected to.

1.3 AUDIO LEVELS FOR BLUETOOTH

Audio levels shall be calculated as Send Loudness Rating, SLR, and Receive Loudness Rating, RLR. The calculation methods are specified in ITU-T Recommendation P.79.

The physical test set-up for Handsets and Headsets is described in ITU-T Recommendation P.51 and P.57

The physical test set-up for speakerphones and "Vehicle handsfree systems" is specified in ITU-T Recommendation P.34.

A general equation for computation of loudness rating (LR) for telephone sets is given by ITU-T recommendations P.79 and is given by

$$LR = -\frac{10}{m}\log_{10}\left(\sum_{i=N_1}^{N_2} 10^{m(s_i - w_i)/10}\right), \qquad \text{(EQ 1)}$$

where

m is a constant (~ 0.2).

w_i = weighting coefficient (different for the various LRs).

S_i = the sensitivity at frequency F_i, of the electro-acoustic path

N_1,N_2, consecutive filter bank numbers (Art. Index: 200-4000 Hz)

(EQ 1) is used for calculating the (SLR) according to Figure 1.1:, and (RLR) according to Figure 1.2:. When calculating LRs one must only include those parts of the frequency band where an actual signal transmission can occur in order to ensure that the additive property of LRs is retained. Therefore ITU-T P.79 uses only the frequency band 200-4000 Hz in LR computations.

1.4 MICROPHONE PATH

1.4.1 SLR measurement model

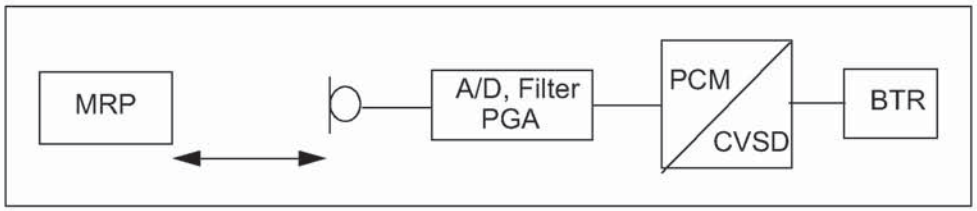


Figure 1.1: SLR measurement set-up.

1.5 LOUDSPEAKER PATH

1.5.1 RLR measurement model

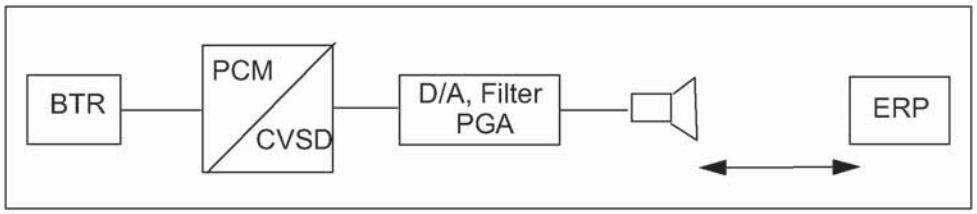


Figure 1.2: RLR measurement set-up.

1.6 BLUETOOTH VOICE INTERFACE

The specification for the Bluetooth voice interface should follow in the first place the *ITU-T Recommendations P.79*, which specifies the loudness ratings for telephone sets. These recommendations give general guidelines and specific algorithms used for calculating the loudness ratings of the audio signal with respect to Ear Reference Point (ERP).

For Bluetooth voice interface to the different cellular system terminals, loudness and frequency recommendations based on the cellular standards should be used. For example, GSM 03.50 gives recommendation for both the loudness ratings and frequency mask for a GSM terminal interconnection with Bluetooth.

1- The output of the CVSD decoder are 16-bit linear PCM digital samples, at a sampling frequency of 8 ksample/second. Bluetooth also supports 8-bit log PCM samples of A-law and μ-law type. The sound pressure at the ear reference point for a given 16-bit CVSD sample, should follow the sound pressure level given in the cellular standard specification.

2- A maximum sound pressure which can be represented by a 16-bit linear PCM sample at the output of the CVSD decoder should be specified according

to the loudness rating, in ITU P.79 and at PGA value of 0 dB. Programmable Gain Amplifiers (PGAs) are used to control the audio level at the terminals by the user. For conversion between various PCM representations: A-law, μ-law and linear PCM, ITU-T G.711, G.712, G.714 give guidelines and PCM value relationships. Zero-code suppression based on ITU-T G.711 is also recommended to avoid network mismatches.

1.7 FREQUENCY MASK

For interfacing a Bluetooth terminal to a digital cellular mobile terminal, a compliance of the CVSD decoder signal to the frequency mask given in the cellular standard, is recommended to guarantee correct function of the speech coders. A recommendation for a frequency mask is given in Table 1.1. Figure 1.3: shows a plot of the frequency mask for Bluetooth (solid line). The GSM frequency mask (dotted line) is shown in Figure 1.3: for comparison.

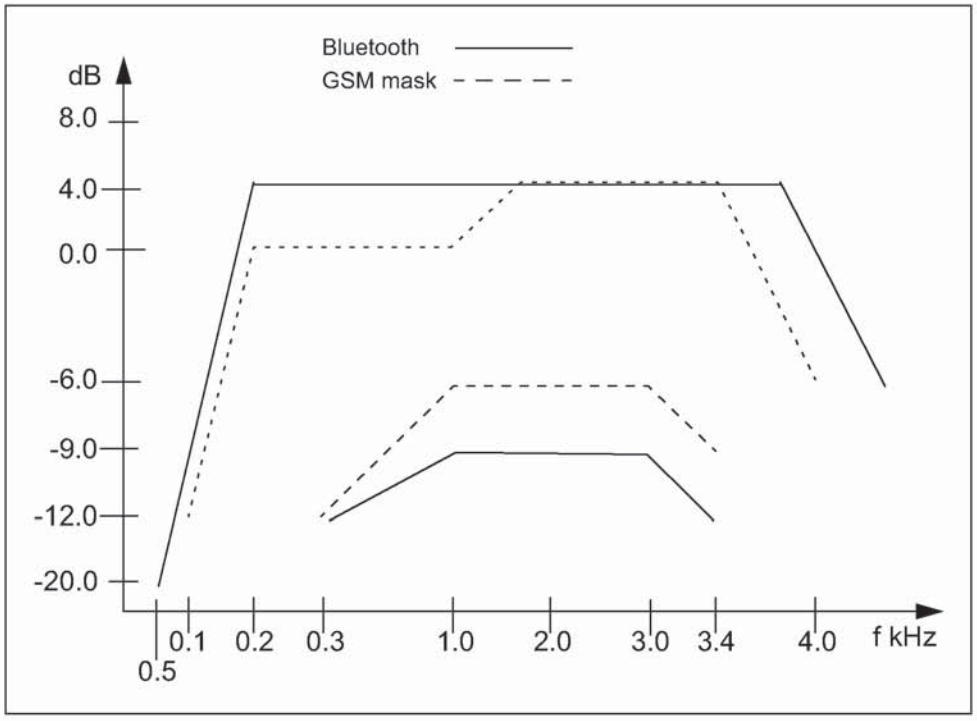


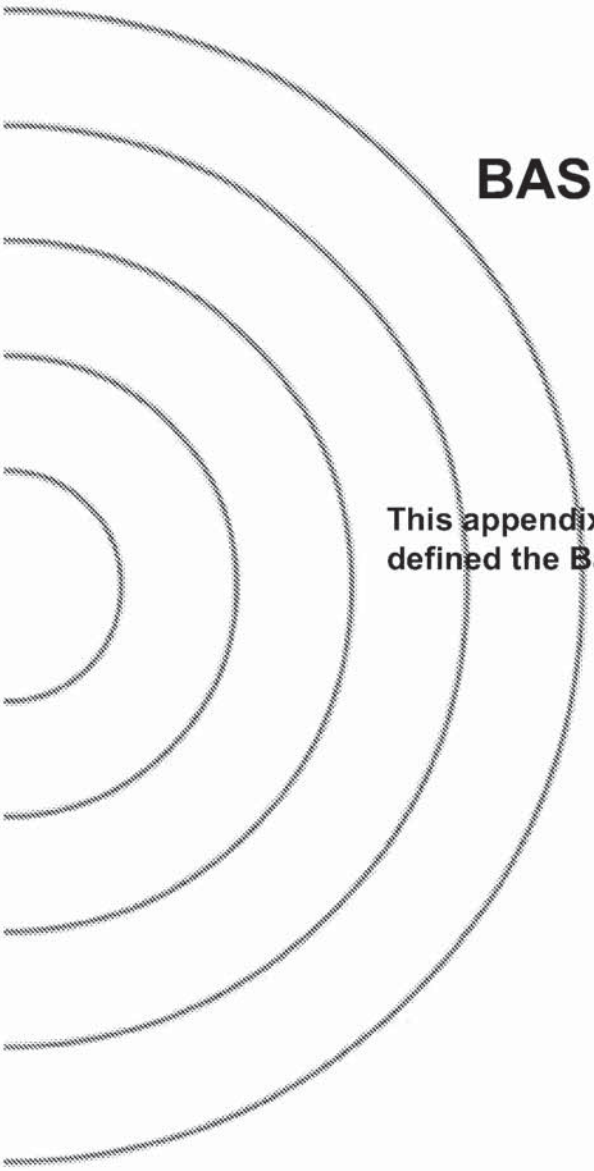
Figure 1.3: Plot of recommended frequency mask for Bluetooth. The GSM send frequency mask is given for comparison (dotted line)

Frequency (Hz)	Upper Limit (dB)	Lower Limit (dB)
50	-20	-
300	4	-12
1000	4	-9
2000	4	-9
3000	4	--9
3400	4	-12
4000	0	-

Table 1.1: Recommended Frequency Mask for Bluetooth

Appendix VI

BASEBAND TIMERS



This appendix contains a list of all timers defined the Baseband Specification.

CONTENTS

1 BASEBAND TIMERS

This appendix contains a list of all timers defined in this specification. Definitions and default values of the timers are listed below.

All timer values are given in slots.

1.1 LIST OF TIMERS

1.1.1 inquiryTO

The *inquiryTO* defines the number of slots the **inquiry** substate will last. Its value is determined by an HCI command.

1.1.2 pageTO

The *pageTO* defines the number of slots the **page** substate can last before a response is received. Its value is determined by an HCI command.

1.1.3 pagerespTO

In the slave, it defines the number of slots the slave awaits the master's response, FHS packet, after sending the page acknowledgment ID packet. In the master, *pagerespTO* defines the number of slots the master should wait for the FHS packet acknowledgment before returning to **page** substate. Both master and slave units should use the same value for this timeout, to ensure common page/scan intervals after reaching *pagerespTO*.

The *pagerespTO* default value is 8 slots.

1.1.4 inqrespTO

In the inquiry scan substate, when a device triggers on an inquiry, it waits a RAND random number of slots and returns to inquiry scan. The *inqRespTO* defines the number of slots the device will stay in the inquiry scan substate without triggering on an inquiry after the RAND wait period. The timeout value should preferably be in multiples of an inquiry train period. Upon reaching the *inqrespTO*, the device returns to **CONNECTION** or **STANDBY** state.

The *inqrespTO* default value is 128 slots.

1.1.5 newconnectionTO

Every time a new connection is started through paging, scanning, master-slave switch or unparking, the master sends a POLL packet as the first packet in the new connection. Transmission and acknowledgment of this POLL packet is used to confirm the new connection. If the POLL packet is not received by the

slave or the response packet is not received by the master for *newconnectionTO* number of slots, both the master and the slave will return to the previous substate.

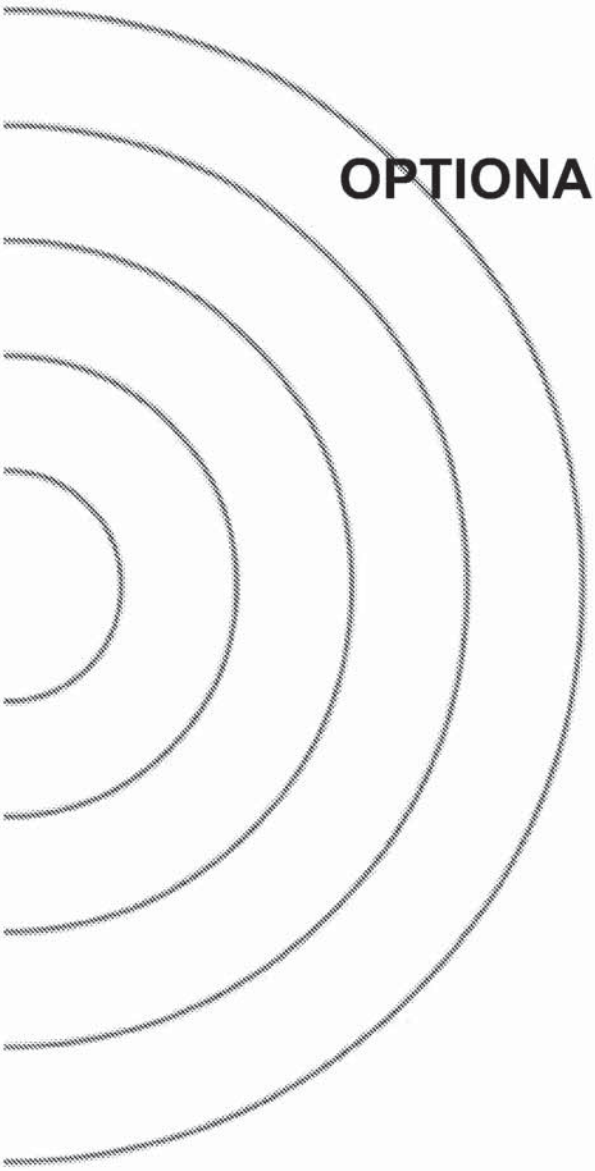
newconnectionTO default value is 32 slots.

1.1.6 supervisionTO

The *supervisionTO* is used by both the master and slave to monitor link loss. If a device does not receive any packets that pass the HEC check and have the proper AM_ADDR for a period of *supervisionTO*, it will reset the link *supervisionTO* will work through hold and sniff periods.

The *supervisionTO* value is determined by an HCI command. At the baseband level a default value that is equivalent to 20 seconds will be used.

Appendix VII



OPTIONAL PAGING SCHEMES

CONTENTS

1 GENERAL

For the access procedure, several paging schemes may be used. There is one mandatory paging scheme which has to be supported by all Bluetooth devices. This scheme has been described in Baseband Specification Section 10.6 on page 99 In addition to the mandatory scheme, a Bluetooth unit may support one or more optional paging schemes. The method used for page scan is indicated in the FHS payload, see Baseband Specification Section 4.4.1.4 on page 56. Three additional optional paging schemes are possible; only optional paging scheme ***I*** has been defined yet.

2 OPTIONAL PAGING SCHEME I

In this section the first optional paging scheme is described which may be used according to the rules specified in Baseband Specification Section 10 on page 95 and LMP Specification Section 3.23 on page 223. The paging code for optional scheme ***I*** is 1 (0 is used for the mandatory scheme), see also Baseband Specification Section 4.4.1.4 on page 56

The main difference between the first optional paging scheme and the mandatory scheme is the construction of the page train sent by the pager. In addition to transmission in the even master slots, the master is transmitting in the odd master slots as well. This allows the slave unit to reduce the scan window.

2.1 PAGE

The same 32 frequencies that are used for transmitting ID-packets in the mandatory paging scheme are used in the optional paging scheme ***I*** (for the construction of page trains, see Baseband Specification Section 11.3.2 on page 135. The 32 frequencies are also split into an **A-train** and **B train**. In contrast to the mandatory scheme, the same 32 frequencies that are used for transmitting are also used for reception trials, to catch the response from the addressed device.

The construction of the page train in optional page scheme ***I*** differs from the page train in the mandatory scheme in two ways:

- the page train consists of 10 slots, or 6.25 ms
- the first 8 slots of the train are used to transmit the ID packets, the 9th slot is used to send a marker packet, and the 10th slot is used for the return of a slave response

The marker packets precede the return slot, indicating the position where the slave can respond, and with which frequency. For the marker codes M_ID, bit-inverted page access codes are used. If a marker code is received at T_m with frequency f_k, a return is expected at nominally T_m+625µs at frequency f_k.

Note: The bit-inverted code M_ID to be used as marker code is beneficial for the implementation of the correlators, because the sign of the correlation peak can be used to identify the mark code during page scanning. Still, the transmitting party is uniquely identified, since inverted ID packets are not identical to the ID packets for the device with bit-wise inverted LAP.

The frequency ordering in the train and the frequencies used for the marker and receive slots change after every train. After 8 trains, all of which have a different appearance, the entire procedure is repeated. It is, therefore, more appropriate to talk about subtrains, each with length 6.25ms. Eight subtrains form a supertrain, which is repeated. An example of a supertrain with the eight subtrains is

illustrated in Figure 2.1. The supertrain length is 50ms. In this example, the **A-train** is assumed with an estimated frequency of f_8; as a consequence, the frequencies selected for the train range from f_0 to f_{15}. The marker codes M_ID are indicated as **M**; the receive (half) slots are indicated as **R**.

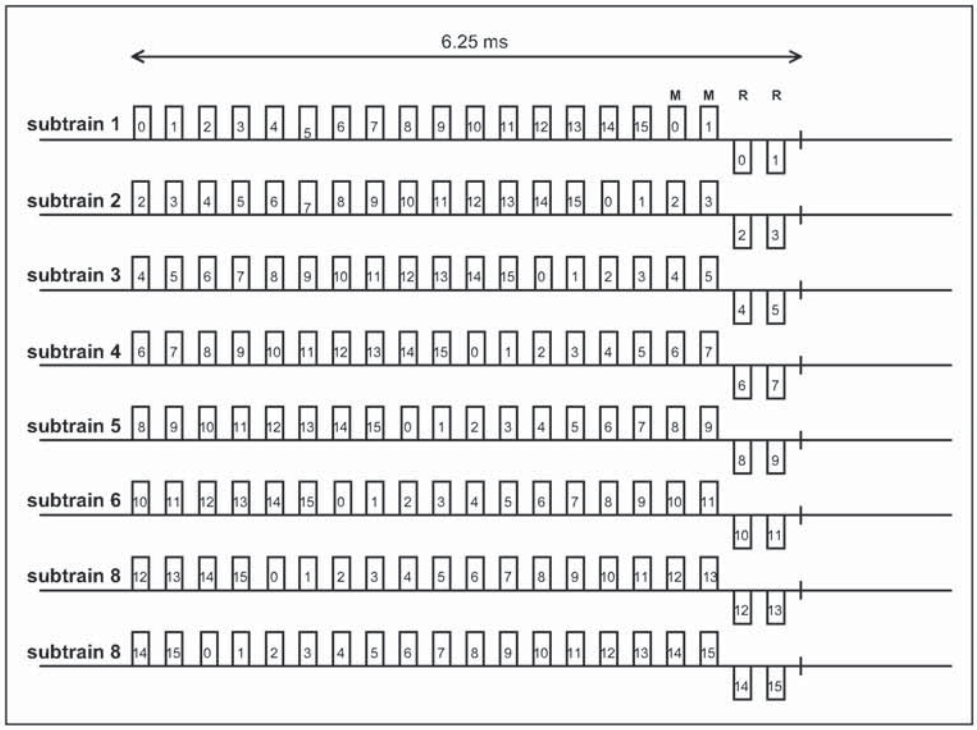


Figure 2.1: Example of train configuration for optional page scheme I.

Corresponding to the paging modes R0, R1 and R2 of the mandatory scheme, the optional scheme supports the same three modes as described for the mandatory scheme in Baseband Specification Section 10.6.2 on page 99

Since the subtrain length is now 10 slots, the 1.28s interval does not cover a multiple of (sub)trains any longer. Therefore, in contrast to the mandatory scheme, the exchange from **A-train** to **B-train** and vice versa is not based on the 1.28s interval, but instead on a multiple number of supertrains. For the R1 and R2 modes, the repetition of a supertrain N_{sup} is indicated in Table 2.1 below.

mode	No SCO link	One SCO link (HV3)	Two SCO links (HV3)
R1	N_{sup}=26	N_{sup}=52	N_{sup}=77
R2	N_{sup}=52	N_{sup}=103	N_{sup}=154

*Table 2.1: Relation between repetition duration of **A**- and **B**-trains and paging modes R1 and R2 when SCO links are present*

In accordance with the phase input to the hop selection scheme *Xp* in (EQ 4) on page 135 in the Baseband Specification (Section 11.3.2), the phase input *Xp_opt* in the optional mode is determined by:

$$Xp\_opt=[k_{offset\_opt} + \mathrm{ST}(cnt)] \bmod 32 \qquad \text{(EQ A1)}$$

where k_{offset_opt} is determined by the A/B selection and the clock estimation of the recipient:

$$k_{offset\_opt} = \begin{cases} \mathrm{CLKE}_{16\text{-}12} + 24 & \text{A-train} \\ \mathrm{CLKE}_{16\text{-}12} + 8 & \text{B-train} \end{cases} \qquad \text{(EQ A2)}$$

and ST is a function determining the structure of the sub- and supertrain:

$$\mathrm{ST}(cnt) = (cnt \bmod 160 - 2*\mathrm{INT}[((cnt \bmod 160) + 18)/20]) \bmod 16 \qquad \text{(EQ A3)}$$

k_{offset_opt} is determined once at the beginning of the repetition period. The CLKE value as is found at the beginning of the repetition interval is taken (the repetition interval being the interval in which the same supertrain is repeated all the time). As long as no train change takes place, k_{offset_opt} is not updated. *cnt* is a counter which is reset to zero at the beginning of the repetition interval and is incremented at the half-slot rate (3200 cycles/s)

The first two ID-packets of a train are transmitted in an even numbered slot.

2.2 PAGE SCAN

The basic page scanning is identical to the mandatory scheme except that a scan duration of 9.5 · 0.625 = 5.9375 ms is sufficient at the slave side.

If a device wants to scan concurrently for the mandatory and optional mode (e.g. after an inquiry response was sent), the device shall try to identify whether the paging party uses the optional scheme after an ID packet was caught. This can be done by train tracing; i.e. the device can determine whether transmission takes place in consecutive slots (optional paging scheme ***I***) or in every over slot (mandatory paging scheme), and/or whether mark codes are sent.

2.3 PAGE RESPONSE PROCEDURES

The page response procedures at the master and slave sides are almost identical to the procedures described in the mandatory mode (see Baseband Specification Section 10.6.4 on page 104). There are two differences:

- The page response routine starts after the transmission and reception of the marker code M_ID
- The ID packet sent by recipient is identical to the frequency in which the marker code was received

For the page response timing, see Figure 2.2 and Figure 2.3.

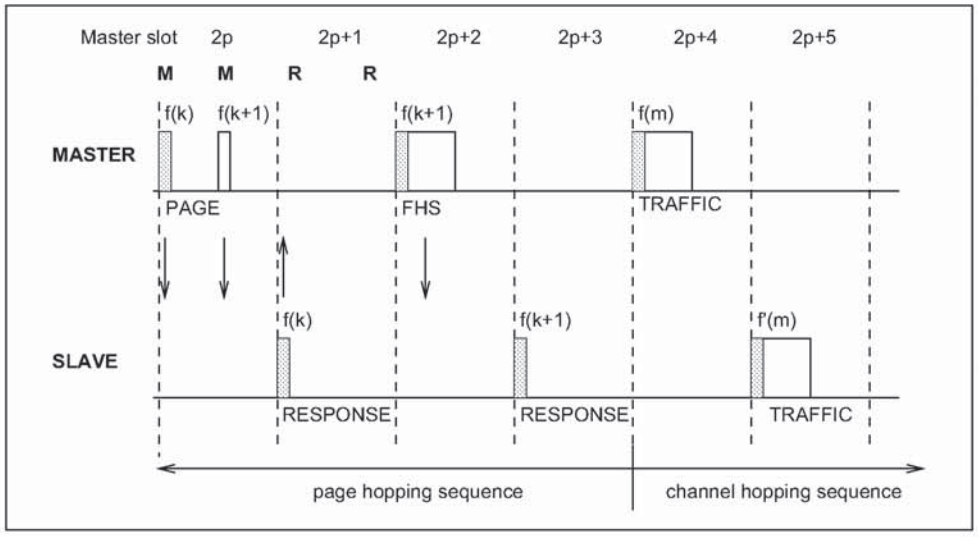


Figure 2.2: Messaging when marker code is received in first half slot of even master slot

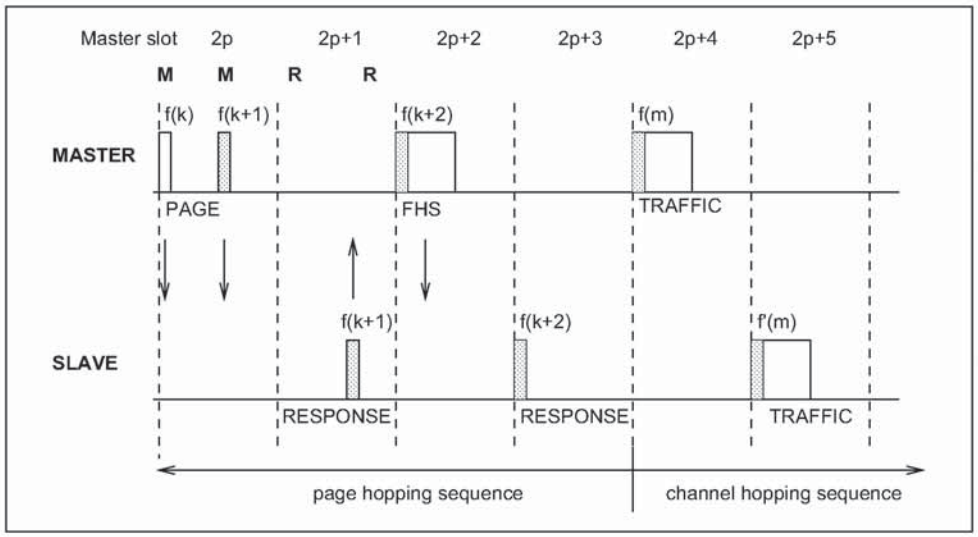


Figure 2.3: Messaging when marker code is received in second half slot of even master slot

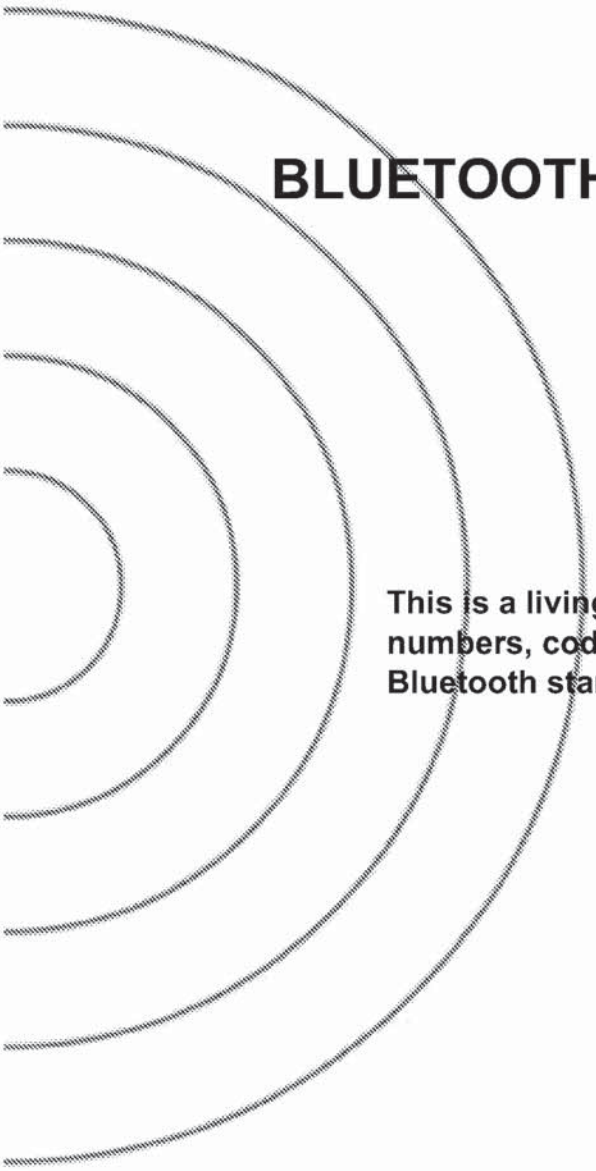
2.4 TRAIN TRACING

This section outlines how a slave may search for the mark code although the current partitioning into A- and B-trains at the master side is not known. Train tracing means that the slave tries to receive as many page access codes from the train as possible, to catch a mark code as soon as possible. When searching for the mark codes, or trying to distinguish between the mandatory paging mode and the optional paging mode, a unit shall set up a hopping pattern for train tracing after the reception of the first access code. The hopping pattern

shall ensure that the transmission and reception is performed with a 50% probability on the same frequency regardless of the actual frequency set (16 frequencies) used for paging.

Appendix VIII

BLUETOOTH ASSIGNED NUMBERS



This is a living document that lists assigned numbers, codes and identifiers in the Bluetooth standard.

CONTENTS

1 BLUETOOTH BASEBAND

1.1 THE GENERAL- AND DEVICE-SPECIFIC INQUIRY ACCESS CODES (DIACS)

The Inquiry Access Code is the first level of filtering when finding Bluetooth devices and services. The main purpose of defining multiple IACs is to limit the number of responses that are received when scanning devices within range.

#	LAP value	Usage
0	0x9E8B33	General/Unlimited Inquiry Access Code (GIAC)
1	0x9E8B00	Limited Dedicated Inquiry Access Code (LIAC)
2-63	0x9E8B01-0x9E8B32, 0x9E8B34-0x9E8B3F	RESERVED FOR FUTURE USE

Table 1.1: The Inquiry Access Codes

The Limited Inquiry Access Code (LIAC) is only intended to be used for limited time periods in scenarios where both sides have been explicitly caused to enter this state, usually by user action. For further explanation of the use of the LIAC, please refer to the Generic Access Profile [7].

In contrast it is allowed to be continuously scanning for the General Inquiry Access Code (GIAC) and respond whenever inquired.

1.2 THE CLASS OF DEVICE/SERVICE FIELD

The Class of Device/Service (CoD) field has a variable format. The format is indicated using the 'Format Type field' within the CoD. The length of the Format Type field is variable and ends with two bits different from '11'. The version field starts at the least significant bit of the CoD and may extend upwards.

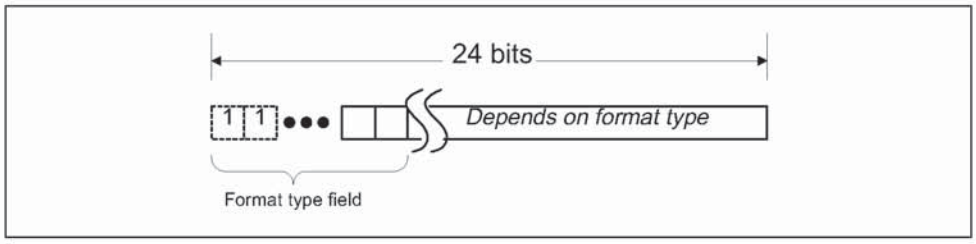


Figure 1.1: General format of Class of Device/Service

In the 'format #1' of the CoD (Format Type field = 00), 11 bits are assigned as a bit-mask (multiple bits can be set) each bit corresponding to a high level generic category of service class. Currently 7 categories are defined. These

are primarily of a 'public service' nature. The remaining 11 bits are used to indicate device type category and other device-specific characteristics.

Any reserved but otherwise unassigned bits, such as in the Major Service Class field, should be set to 0.

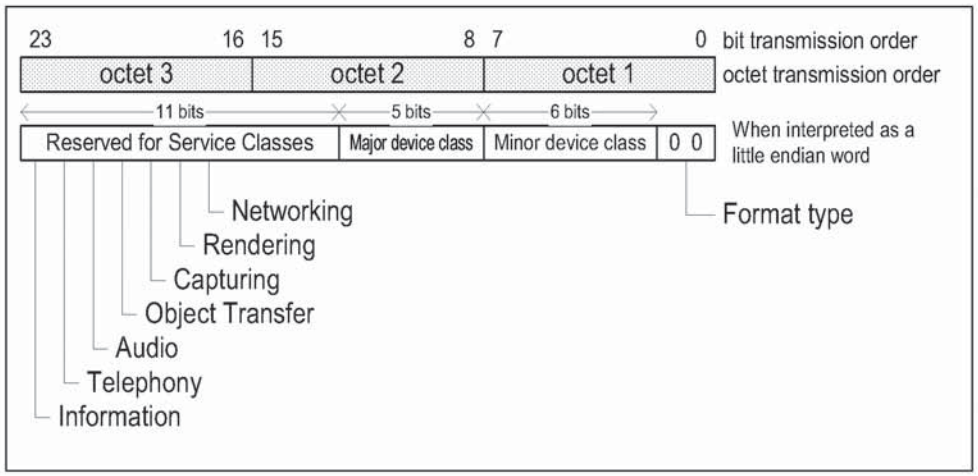


Figure 1.2: The Class of Device/Service field (format type 1). Note the order in which the octets are sent on the air and stored in memory.

1.2.1 Major Service Classes

Bit no	Major Service Class
13	Limited Discoverable Mode[1]
14	(reserved)
15	(reserved)
16	(reserved)
17	Networking (LAN, Adhoc, …)
18	Rendering (Printing, Speaker, …)
19	Capturing (Scanner, Microphone, …)
20	Object Transfer (v-Inbox, v-Folder, …)
21	Audio (Speaker, Microphone, Headset service, …)
22	Telephony (Cordless telephony, Modem, Headset service, …)
23	Information (WEB-server, WAP-server, …)

Table 1.2: Major Service Classes

1. As defined in [7]

1.2.2 Major Device Classes

The Major Class segment is the highest level of granularity for defining a Bluetooth Device. The main function of a device is used to determine the major class grouping. There are 32 different possible major classes. The assignment of this Major Class field is defined in Table 1.3.

Code (bits)					Major Device Class
12	11	10	9	8	bit no of CoD
0	0	0	0	0	Miscellaneous[1]
0	0	0	0	1	Computer (desktop, notebook, PDA, organizers, …)
0	0	0	1	0	Phone (cellular, cordless, payphone, modem, …)
0	0	0	1	1	LAN Access Point
0	0	1	0	0	Audio (headset, speaker, stereo, …)
0	0	1	0	1	Peripheral (mouse, joystick, keyboards, …)
x	x	x	x	x	Range 0x06 to 0x1E reserved
1	1	1	1	1	Unclassified, specific device code not assigned

Table 1.3: Major Device Classes

1. Used where a more specific Major Device Class code is not suited (but only as specified in this document. Devices that do not have a major class code assigned can use the all-1 code until 'classified')

1.2.3 The Minor Device Class field

The 'Minor Device Class field' (bits 7 to 1 in the CoD), are to be interpreted only in the context of the Major Device Class (but independent of the Service Class field). Thus the meaning of the bits may change, depending on the value of the 'Major Device Class field'. When the Minor Device Class field indicates a device class, then the primary device class should be reported, e.g. a cellular phone that can also work as a cordless handset should use 'Cellular' in the minor device class field.

1.2.4 Minor Device Class field - Computer Major Class

Code (bits)						Minor Device Class
7	6	5	4	3	2	bit no of CoD
0	0	0	0	0	0	Unclassified, code for device not assigned
0	0	0	0	0	1	Desktop workstation
0	0	0	0	1	0	Server-class computer
0	0	0	0	1	1	Laptop
0	0	0	1	0	0	Handheld PC/PDA (clam shell)
0	0	0	1	0	1	Palm sized PC/PDA
x	x	x	x	x	x	Range 0x06-0x7F reserved

Table 1.4: Sub Device Class field for the 'Computer' Major Class

1.2.5 Minor Device Class field - Phone Major Class

Code (bits)						Minor Device Class
7	6	5	4	3	2	bit no of CoD
0	0	0	0	0	0	Unclassified, code not assigned
0	0	0	0	0	1	Cellular
0	0	0	0	1	0	Cordless
0	0	0	0	1	1	Smart phone
0	0	0	1	0	0	Wired modem or voice gateway
x	x	x	x	x	x	Range 0x05-0x7F reserved

Table 1.5: Sub Device Classes for the 'Phone' Major Class

1.2.6 Minor Device Class field - LAN Access Point Major Class

Code (bits)			Minor Device Class
7	6	5	bit no of CoD
0	0	0	Fully available
0	0	1	1-17% utilized
0	1	0	17 - 33% utilized
0	1	1	33 - 50% utilized
1	0	0	50 - 67% utilized
1	0	1	67 - 83% utilized
1	1	0	83 - 99% utilized
1	1	1	No Service Available[1]

Table 1.6: The LAN Access Point Load Factor field

1. "Device is fully utilized and cannot accept additional connections at this time, please retry later"

The exact loading formula is not standardized. It is up to each LAN Access Point implementation to determine what internal conditions to report as a utilization percentage. The only requirement is that the number reflects an ever-increasing utilization of communication resources within the box. As a recommendation, a client that locates multiple LAN Access Points should attempt to connect to the one reporting the lowest load.

Code (bits)			Minor Device Class
4	3	2	bit no of CoD
0	0	0	Unclassified (use this value if no other apply)
x	x	x	range 0x01-0x0F reserved

Table 1.7: Reserved sub-field for the LAN Access Point

1.2.7 Minor Device Class field - Audio Major Class

Code (bits)						Minor Device Class
7	6	5	4	3	2	bit no of CoD
0	0	0	0	0	0	Unclassified, code not assigned
0	0	0	0	0	1	Device conforms to the Headset profile [9]
x	x	x	x	x	x	Range 0x02-0x7F reserved

Table 1.8: Sub Device Classes for the 'Audio' Major Class

2 LINK MANAGER PROTOCOL (LMP)

2.1 THE LINK MANGER VERSION PARAMETER

Parameter name	Assigned values	
VersNr	0	Bluetooth LMP 1.0, [2]
	1-255	(reserved)

Table 2.1: The LMP Version Parameter Values

2.2 THE LMP_COMPID PARAMETER CODES

This is the parameter used in the LMP Version procedure.

Code	Company
0	Ericsson Mobile Communications
1	Nokia Mobile Phones
2	Intel Corp.
3	IBM Corp.
4	Toshiba Corp.
5 - 65534	(reserved)
65535	Unassigned. For use in internal and interoperability tests before a Company ID has been assigned. May not be used in products.

Table 2.2: The LMP_CompId parameter codes

3 LOGICAL LINK CONTROL AND ADAPTATION PROTOCOL (L2CAP)

Please see Section 4.3 for assigned PSM values.

3.1 CHANNEL IDENTIFIERS

Destination CID	Protocol/usage	Reference
0x0000	Illegal, should not be used	[3]
0x0001	L2CAP signalling channel	[3]
0x0002	L2CA connection less data	[3]
0x0003 - 0x003F	(reserved)	

Table 3.1: Pre-defined L2CAP Channel Identifiers

3.2 PROTOCOL AND SERVICE MULTIPLEXOR (PSM)

Protocol	PSM	Reference
SDP	0x0001	[4]
RFCOMM	0x0003	[5]
TCS-BIN	0x0005	[6]
TCS-BIN-CORDLESS	0x0007	[6]

Table 3.2: Assigned Protocol and Service Multiplexor values (PSM)

4 SERVICE DISCOVERY PROTOCOL (SDP)

4.1 UNIVERSALLY UNIQUE IDENTIFIER (UUID) SHORT FORMS

The Bluetooth Service Discovery Protocol (SDP) specification defines a way to represent a range of UUIDs (which are nominally 128-bits) in a shorter form. A *reserved* range of 2^{32} values can be represented using 32-bits (denoted uuid32). Of these, a sub-range of 2^{16} values can be represented using only 16-bits (denoted uuid16). Any value in the 2^{32} range that is not assigned in this document is reserved pending future revisions of this document. In other words, no value in this range may be used except as specified in this or future revisions of this document. UUID values outside of this range can be allocated as described in [19] for any purpose the allocater desires.

4.2 BASE UNIVERSALLY UNIQUE IDENTIFIER (UUID)

The Base UUID is used for calculating 128-bit UUIDs from 'short UUIDs' (uuid16 and uuid32) as described in the SDP Specification [4].

Mnemonic	UUID
BASE_UUID	00000000-0000-1000-8000-00805F9B34FB

4.3 PROTOCOLS

Mnemonic	UUID	Name	Ref.
SDP	uuid16: *0x0001*[1]	sdp.bt	[4]
RFCOMM	uuid16: *0x0003*	com.bt	[5]
TCS-BIN	uuid16: *0x0005*	tcs.bt	[6]
L2CAP	uuid16: *0x0100*		[3]
IP	uuid16: *0x0009*		
UDP	uuid16: *0x0002*		
TCP	uuid16: *0x0004*		
TCS-AT	uuid16: *0x0006*	modem	
OBEX	uuid16: *0x0008*	obex	
FTP	uuid16: *0x000A*	ftp	
HTTP	uuid16: *0x000C*	http	
WSP	uuid16: *0x000E*	wsp	

Table 4.1: Protocol Universally Unique Identifiers and Names

1. 'Short UUID'

4.4 SERVICE CLASSES

Mnemonic	UUID	Profile[1]	AbstractName
ServiceDiscoveryServerServiceClassID	uuid16: *0x1000*		
BrowseGroupDescriptorServiceClassID	uuid16: *0x1001*		
PublicBrowseGroup	uuid16: *0x1002*		
SerialPort	uuid16: *0x1101*	[7]	serial.bt
LANAccessUsingPPP	uuid16: *0x1102*		
DialupNetworking	uuid16: *0x1103*	[13]	
IrMCSync	uuid16: *0x1104*	[17]	
OBEXObjectPush	uuid16: *0x1105*	[16]	
OBEXFileTransfer	uuid16: *0x1106*	[15]	
IrMCSyncCommand	uuid16: *0x1107*	[17]	
Headset	uuid16: *0x1108*	[7]	headset
CordlessTelephony	uuid16: *0x1109*	[10]	
Intercom	uuid16: *0x1110*	[11]	
Fax	uuid16: *0x1111*	[12]	
HeadsetAudioGateway	uuid16: 0x1112	[7]	
PnPInformation	uuid16: *0x1200*		
GenericNetworking	uuid16: *0x1201*	n/a	
GenericFileTransfer	uuid16: *0x1202*	n/a	
GenericAudio	uuid16: *0x1203*	n/a	
GenericTelephony	uuid16: *0x1204*	n/a	

Table 4.2: Service Class Identifiers and Names

1. If the specified Service Class directly and exactly implies a certain Profile, the Profile is indicated here (i.e. for concrete Service Classes). Leave empty for abstract Service Classes.

The Profile column in Table 4.2 indicates which Service Class identifiers that also directly corresponds to a Bluetooth Profile. It is not allowed to use the Service Class UUID unless the service complies with the specified Profile. These UUIDs might also appear as Profile Identifiers in the BluetoothProfileDescriptorList attribute.

4.5 ATTRIBUTE IDENTIFIER CODES

Mnemonic	Attribute ID	Reference
ServiceRecordHandle	0x0000	[4] *Bluetooth Service Discovery Protocol (SDP)*, Bluetooth SIG
ServiceClassIDList	0x0001	
ServiceRecordState	0x0002	
ServiceID	0x0003	
ProtocolDescriptorList	0x0004	
BrowseGroupList	0x0005	
LanguageBaseAttributeIDList	0x0006	
ServiceInfoTimeToLive	0x0007	
ServiceAvailability	0x0008	
BluetoothProfileDescriptorList	0x0009	
DocumentationURL	0x000A	
ClientExecutableURL	0x000B	
Icon10	0x000C	
IconURL	0x000D	
Reserved	0x000E-0x01FF	
ServiceName	0x0000 + b[1]	
ServiceDescription	0x0001 + b	
ProviderName	0x0002 + b	
VersionNumberList	0x0200	
ServiceDatabaseState	0x0201	
GroupID	0x0200	
Remote audio volume control	0x0302[2]	[7]
External network	0x0301	[10]
Service Version	0x0300	
Supported Data Stores List	0x0301	[17]
Supported Formats List	0x0303	[16]

Table 4.3: Attribute Identifiers

Mnemonic	Attribute ID	Reference
Fax Class 1 Support	0x0302	[12]
Fax Class 2.0 Support	0x0303	
Fax Class 2 Support	0x0304	
Audio Feedback Support	0x0305	

Table 4.3: Attribute Identifiers

1. 'b' in this table represents a base offset as given by the LanguageBaseAttributeIDList attribute. For the primary language, 'b' must be equal to 0x0100 as described in the SDP specification.
2. Items in *italic* are tentative values in this version of the document.

4.6 PROTOCOL PARAMETERS

Protocol	Parameter mnemonic	Index
L2CAP	PSM	1
TCP or UDP	Port	1
RFCOMM	Channel	1

Table 4.4: Protocol Parameters

4.7 HOST OPERATING ENVIRONMENT IDENTIFIERS

4.7.1 ClientExecutableURL substitution strings

The operating environment identifier strings have the following format[1]:

<cpu_type>-<manufacturer>-[<kernel>-]<os>[<version>][-<object_format>]

The general rule is that is that a new identifier should only be defined as required to differentiate incompatible operating environments concerning an executable file image. That is, for example different <version>-tags should not be used for compatible versions of the same operating system.

1. It is based on a format used by the GNU AutoConfig tools

Currently defined tags:

CPU-Type ID	Description
alpha	Digital Alpha* compatible
arm	ARM* core or compatible
i86	Any Intel* 80x86-family compatible CPU
i960	Intel* i960 compatible
jvm	Java Virtual Machine*
mips	MIPS MIPS* compatible
ppc	IBM/Motorola PowerPC* compatible
sh3	Hitachi SH-3* compatible
sh4	Hitachi SH-4* compatible
sparc	Sun Sparc* compatible
Kernel ID	**Description**
chorus, linux, javaos, os9, qnx, vxworks	
<os>	An 'OS identifier' as listed below, might appear in the <kernel> field when the requested OS platform is Java based.
OS+Version-Identifiers	
amigaos, beos4.5, ejava, epocc, epoce, epocq, epocs, gnu, jre1.1, jre1.2, macos, macosx, os2, os9, palmos, pjava, pjava1.1, photon, plan9, qnx, rtjava, win95, win98, win2000, wince, winnt4	
Object Format Identifiers[1]	
aout, bout, coff, elf, jar	
Manufacturer Identifiers	
amiga*, apple*, be*, ericsson*, ibm*, intel*, lucent*, microsoft*, microware*, motorola*, nokia*, palm*, psion*, qnx*, sun*, symbian*, toshiba*, unknown[2]	

1. Only applicable when the object format is not otherwise uniquely implied by the identifier string.
2. Use when no other applies.

For Linux, the 'manufacturer' field may be used to indicate Linux distribution if so required (in which case <version> indicates the version of the distribution). Otherwise use 'unknown'.

Linux Distribution Identifiers
caldera, debian, dlx, doslinux, linuxpro, linuxware, mandrake, mklinux, redhat, slackware, stampede, suse, turbolinux, yggdrasil

Example Operating Environment Identifier Strings		
i86-microsoft-win95	ppc-apple-macos	i86-redhat-linux-gnu6
i86-microsoft-win98	m68k-apple-macos	ppc-mklinux-linux-gnu
i86-microsoft-winnt4	ppc-apple-macosx	
alpha-microsoft-winnt4	i86-apple-macosx	
i86-microsoft-win2000	m68k-amiga-amigaos	
alpha-microsoft-win2000	ppc-amiga-amigaos	
i86-be-beos4.5	jvm-sun-jre1.2	
ppc-be-beos4.5	jvm-sun-pjava1.1	
arm-symbian-epoc3	jvm-sun-ejava	
i86-unknown-linux-gnu	m68k-palm-palmos-coff	
sh3-microsoft-wince	ppc-ibm-vxworks-pjava1.2	
arm-microsoft-wince	sparc-sun-javaos-jre1.2	

4.7.2 IconURL substitution strings

The IconURL operating environment identifier strings have the following general format:

<horizontal_pixels>x<vertical_pixels>x<color_depth>[m].<file_format>

The optional tag 'm' indicates monochrome or grayscale. The host is free to try to match/request any graphics file format as indicated by a <file_format> tag, however at a minimum files conforming to the Portable Network Graphic standard [18] should be made available at the resulting URL (indicated by <file_format>=png)[2].

File format tag	Description
png	Portable Network Graphics [18]
gif	Graphics Interchange File format
bmp	Windows bitmap

Currently defined IconURL Icon format identifier strings:

Example Icon format Identifier Strings	
32x32x8.png	256 color 32 by 32 icon (or 255 colors + transparent)
16x16x8.png	
16x16x1m.png	Black and white (or monochrome + transparent)
10x10x2m.png	4 gray-scales

2. The use of PNG, and whether a subset of PNG should be required, is currently pending further investigation.

5 REFERENCES

[1] *Bluetooth Baseband Specification*, Bluetooth SIG

[2] *Bluetooth Link Manager Specification,* Bluetooth SIG

[3] *Logical Link Control and Adaptation Protocol Specification*, Bluetooth SIG

[4] *Bluetooth Service Discovery Protocol (SDP)*, Bluetooth SIG

[5] *RFCOMM with TS 07.10,* Bluetooth SIG

[6] *Bluetooth Telephony Control Specification / TCS Binary*, Bluetooth SIG

[7] *Generic Access Profile*, Bluetooth SIG

[8] *Serial Port Profile*, Bluetooth SIG

[9] *Headset Profile*, Bluetooth SIG

[10] *Cordless Telephony Profile*, Bluetooth SIG

[11] *Intercom Profile*, Bluetooth SIG

[12] *Fax Profile*, Bluetooth SIG

[13] *Dial-up Networking Profile*, Bluetooth SIG

[14] *IrDA Interoperability*, Bluetooth SIG

[15] *File Transfer Profile*, Bluetooth SIG

[16] *Object Push Profile*, Bluetooth SIG

[17] *Synchronization Profile*, Bluetooth SIG

[18] *Portable Network Graphics (PNG),* http://www.w3.org/Graphics/PNG

[19] *UUIDs and GUIDs*, P. J. Leach et al, http://www.ietf.org/internet-drafts/draft-leach-uuids-guids-01.txt

6 TERMS AND ABBREVIATIONS

LMP	Link Management Protocol
L2CA	Logical Link Control and Adaptation, protocol multiplexer layer for Bluetooth
MTU	Maximum Transmission Unit
SAP	Service Access Points
Baseband	Baseband Protocol
Service Discovery	The ability to discover the capability of connecting devices or hosts.
PnP	Plug and Play
SAR	Segmentation and Reassembly
IP	Internet Protocol
IrDA	InfraRed Data Association
PPP	Point-to-Point Protocol
IETF	Internet Engineering Task Force
RFC	Request For Comments

7 LIST OF FIGURES

8 LIST OF TABLES

Appendix IX

MESSAGE SEQUENCE CHARTS

Between Host and Host Controller/Link Manager

This document shows examples of inter-working between HCI Commands and LM Protocol Data Units in form of message sequence charts. It helps to understand and to correctly use the HCI Commands.

CONTENTS

1 INTRODUCTION

The goal of this document is to show the interworkings of HCI-Commands and LM-PDUs. It focuses on the message sequence charts for the procedures specified in [3] "Bluetooth Host Controller Interface Functional Specification" with regard to LM Procedures from [2] "Link Manager Protocol".

We illustrate here the most useful scenarios, but we do not cover all possible alternatives. Furthermore, the message sequence charts do not consider the transfer error over Air Interface or Host Interface. In all message sequence charts it is assumed that all events are not masked, so the Host Controller will not filter out any events.

Notation used in the message sequence charts:

Box:

- Replaces a group of transactions
- Indicates the start of a procedure or a sub-scenario

Note: in a message sequence chart where several sub-scenarios exist, the sub-scenarios can be executed optionally, consequently, exclusively or independently from each other.

Hexagon:

- Indicates a condition that is needed to start the transaction below this hexagon

Arrow:

- Represents a message, signal or transaction

Comment:

- "/* … */" indicates editor comments

2 SERVICES WITHOUT CONNECTION REQUEST

2.1 REMOTE NAME REQUEST

The service Remote Name Request is used to find out the name of the remote BT Device without an explicit ACL Connection request.

Sending an HCI_Remote_Name_Request (BD_ADDR, Page_Scan_ Repetition_Mode, Page_Scan_Mode, Clock_Offset), the Host expects that its local BT Device will automatically try to connect to the remote BT Device (with the specified BD_ADDR). Then the local BT Device should try to get the name, to disconnect, and finally to return the name of the remote BT Device back to the Host (see Figure 2.1 Remote Name Request: sub-scenario 1).

Note: if an ACL Connection already exists (see Figure 2.1 Remote Name Request: sub-scenario 2), the Remote Name Request procedure will be executed like an optional service. No Paging and no ACL Detachment need to be done.

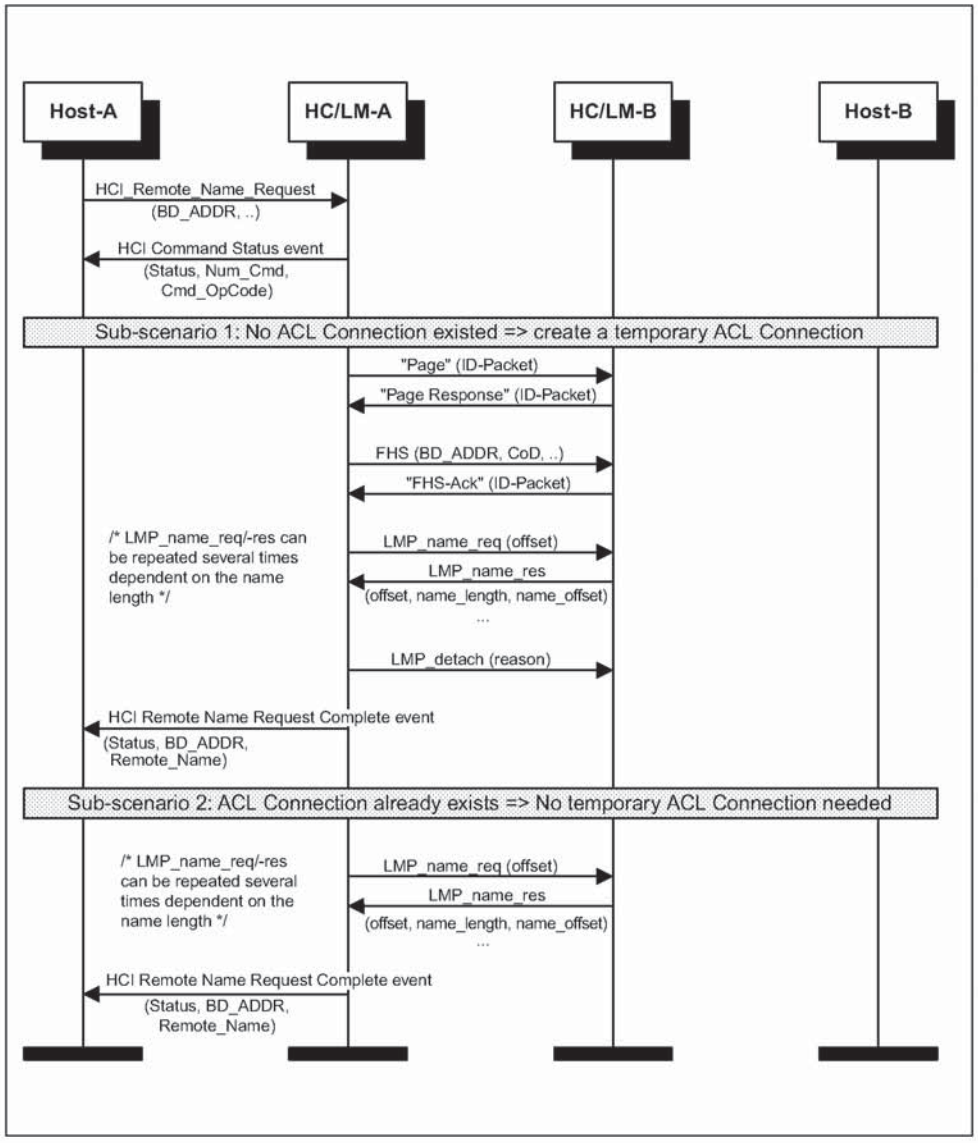


Figure 2.1: Remote Name Request

2.2 ONE-TIME INQUIRY

Inquiry is used to detect and collect nearby BT Devices. When receiving the command HCI_Inquiry (LAP, Inquiry_Length, Num_Responses), HC will start the baseband inquiry procedure with an Inquiry Access Code (derived from the specified LAP) and Inquiry Length. When Inquiry Responses are received, HC will filter out and then return the information related to the found BT Devices using one or several Inquiry Result events (Num_Responses, BD_ADDR[I], Page_Scan_Repetition_Mode[i], Page_Scan_Period_Mode[i], Page_Scan_Mode[i], Class_Of_Device[i], Clock_Offset[i]) to the Host.

The filtering of found BT Devices is specified in HCI_Set_Event_Filter (Filter_Type, Filter_Condition_Type, Condition) with the Filter_Type = Inquiry Result. When the Inquiry procedure is completed, Inquiry Complete event (Status, Num_Responses) must be returned to the Host. Otherwise, the command HCI_Inquiry_Cancel( ) will be used to directly stop the inquiry procedure.

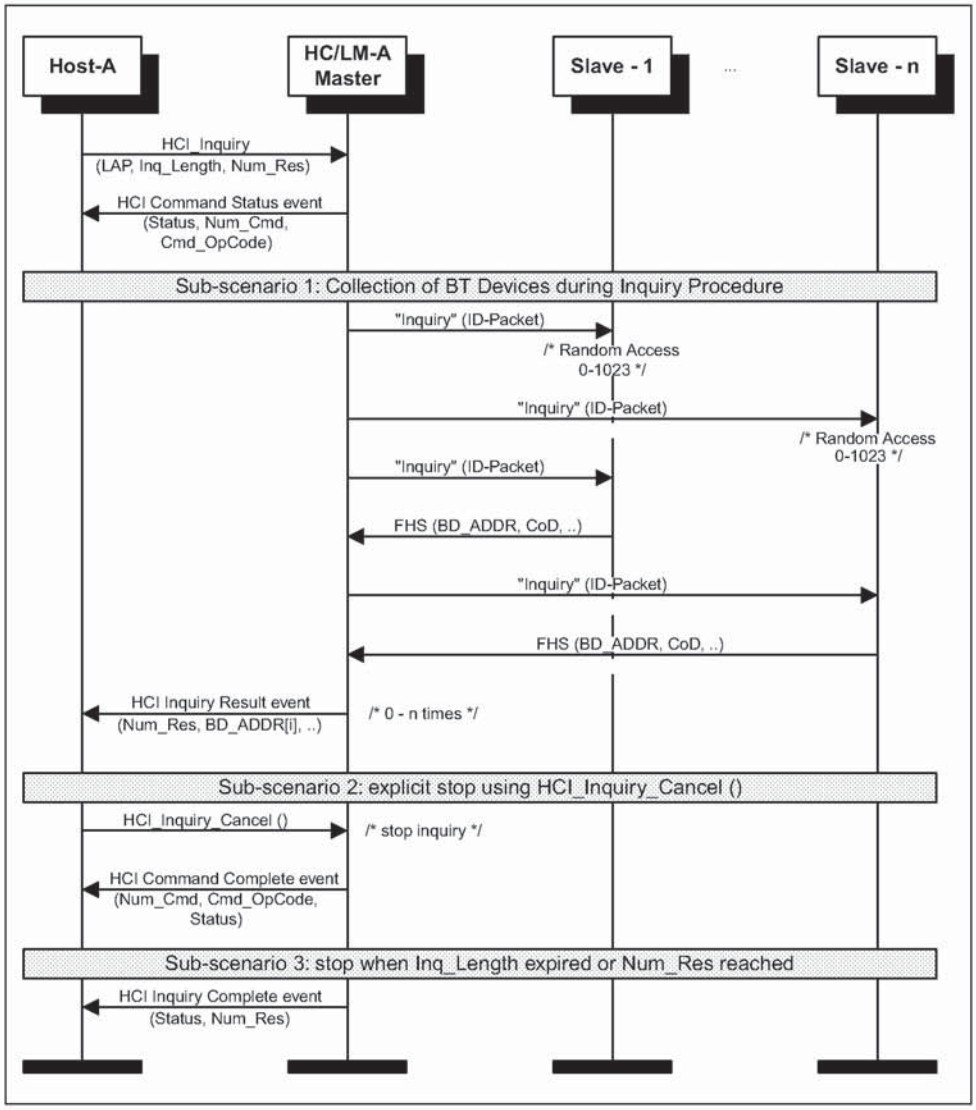


Figure 2.2: One-Time Inquiry

2.3 PERIODIC INQUIRY

Periodic inquiry is needed when the inquiry procedure is to be repeated periodically. Receipt of the command HCI_Periodic_Inquiry_Mode (Max_Period_Length, Min_Period_Length, LAP, Inquiry_Length, Num_Responses) HC will start the periodic Inquiry Mode with the specified

parameters Max_Period_Length, Min_Period_Length, Inquiry_Access_code (derived from LAP) and Inquiry_Length. As in the one-time Inquiry procedure, only BT Devices that are specified in the HCI_Set_Event_Filter (Filter_Type, Filter_Condition_Type, Condition) with the Filter_Type = Inquiry Result will not be filtered out. Therefore, in the inquiry cycle, one or several Inquiry Result events (Num_Responses, BD_ADDR[i], Page_Scan_Repetition_ Mode[i], Page_Scan_Period_Mode[i], Page_Scan_Mode[i], Class_Of_ Device[i], Clock_Offset[i]) and Inquiry Complete event (Status, Num_Responses) will be returned to the Host with one, or a list of, found BT Devices. The periodic Inquiry can be stopped using HCI_Exit_Periodic_ Inquiry_Mode( ).

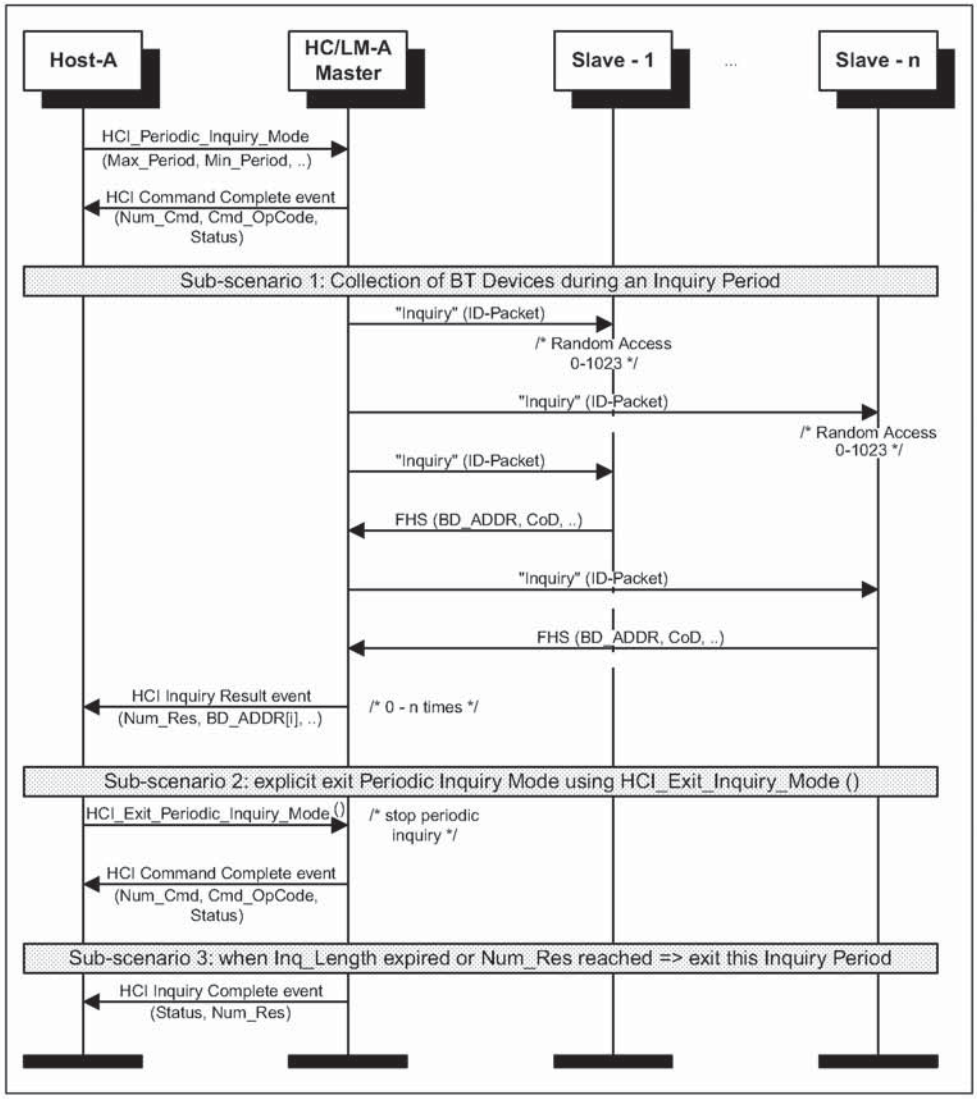


Figure 2.3: Periodic Inquiry

3 ACL CONNECTION ESTABLISHMENT AND DETACHMENT

The overview of the ACL Connection establishment and detachment is shown in Figure 3.1 Overview of ACL Connection establishment and detachment.

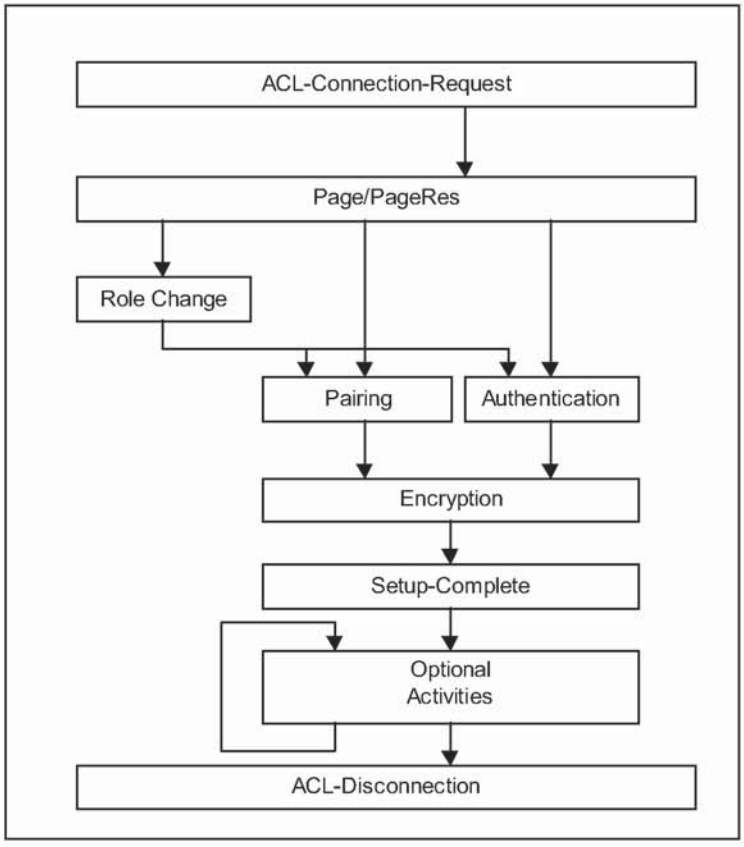


Figure 3.1: Overview of ACL Connection establishment and detachment

3.1 ACL CONNECTION REQUEST PHASE

The ACL Connection Request phase is identified between the HCI_Create_Connection (BD_ADDR, Packet_Type, Page_Scan_Repetition_Mode, Page_Scan_Mode, Clock_Offset, Allow_Role_Switch) from the master side and the response from the slave side with rejection or acceptation on the LM level. Three alternative sub-scenarios are shown in Figure 3.2, "ACL Connection Request phase," on page 1044.

Sub-scenario 1: Slave rejects ACL Connection Request

If the ACL Connection request is rejected by slave, a Connection Complete event (Status, Connection_Handle, BD_ADDR, Link_Type, Encryption_Mode) will be then returned to Host, whereby the Status will be copied from the Reason parameter of the command HCI_Reject_Connection_Request (Reason, BD_ADDR). The parameters Connection_Handle and Encryption_Mode will be meaningless.

Sub-scenario 2: Slave accepts ACL Connection Request

When the slave responds with LMP_accepted ( ) correspondent to LMP_host_connection_req ( ), the ACL Connection Request is accepted. The master will continue with the ACL Connection Setup, where pairing, authentication or encryption will be executed.

Sub-scenario 3: Slave accepts ACL Connection Request with Role Change

This case is identified when the slave sends an LMP_switch_req ( ) to initiate Role Change. If the master accepts, the baseband Master-Slave Switch will be executed. Thereafter, the ACL Connection Setup will continue.

Note: on the slave side, an incoming connection request can be automatically accepted by using HCI_Set_Event_Filter (Filter_Type, Filter_Condition_Type, Condition) with the Filter_Type = 0x02 /*Connection_Setup*/.

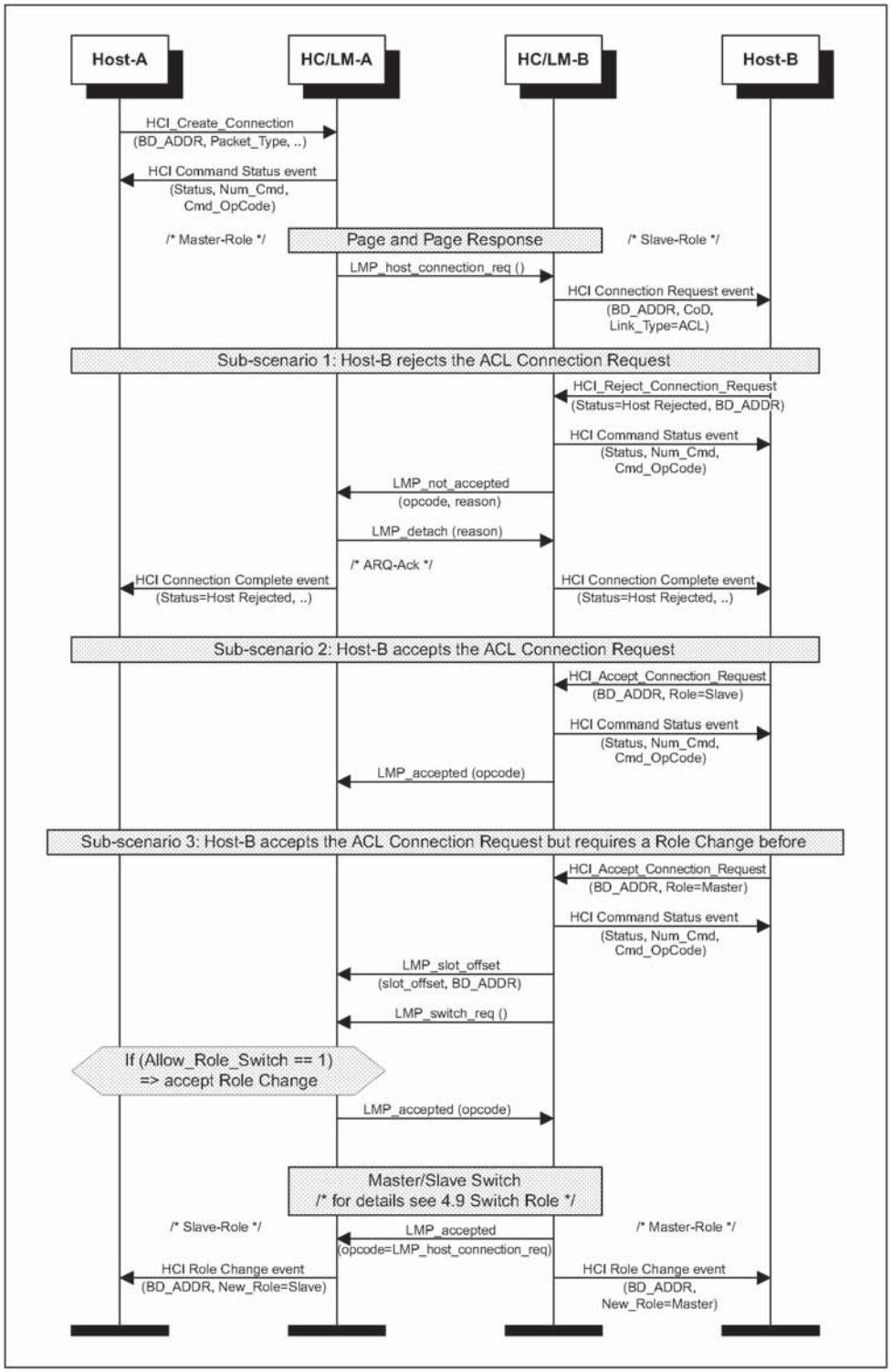


Figure 3.2: ACL Connection Request phase

3.2 ACL CONNECTION SETUP PHASE

If the ACL Connection Request phase was successful, the ACL Connection Setup phase will start, with the goal of executing security procedures like pairing, authentication and encryption. The ACL Connection Setup phase is successfully finished when LMP_setup_complete ( ) is exchanged and the Connection Complete event (Status=0x00, Connection_Handle, BD_ADDR, Link_Type, Encryption_Mode) is sent to the Host.

3.2.1 Pairing

If authentication is required and the BT Devices to be connected don't have a common link key, the pairing procedure on LM Level will be executed using the PIN Input from Host. During the pairing, the authentication- and link key creation procedures will be done. Note: the created Link Key can be stored either in the BT Device or in the Host.

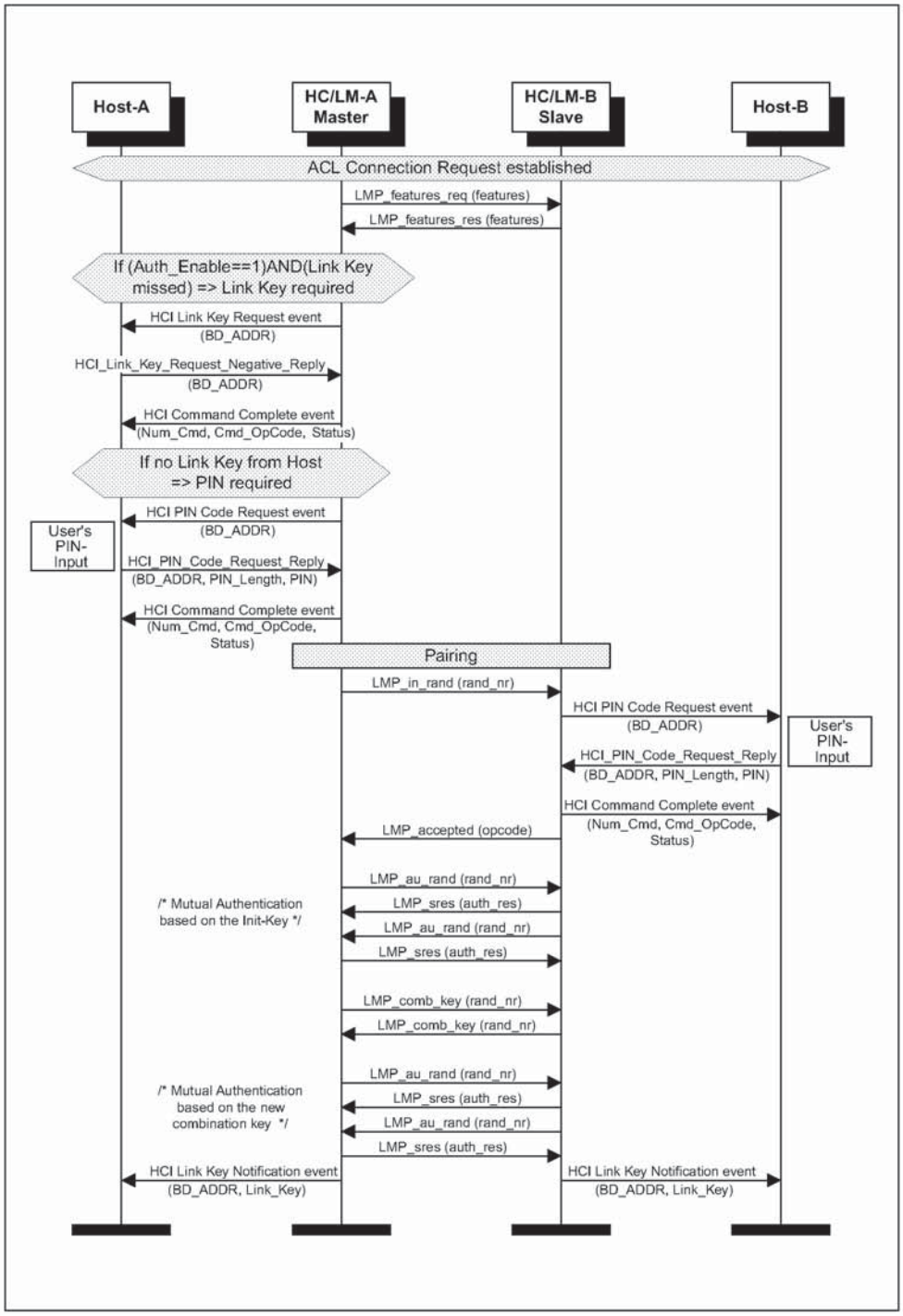


Figure 3.3: ACL Connection setup with pairing

3.2.2 Authentication

If a common link key already exists between the BT Devices, pairing is not needed. Note: a Link Key created during pairing can be stored either in the BT Device or in the Host. If the parameter Authentication_Enable is set, the authentication procedure has to be executed. Here, the MSC only shows the case when Authentication_Enable is set on both sides.

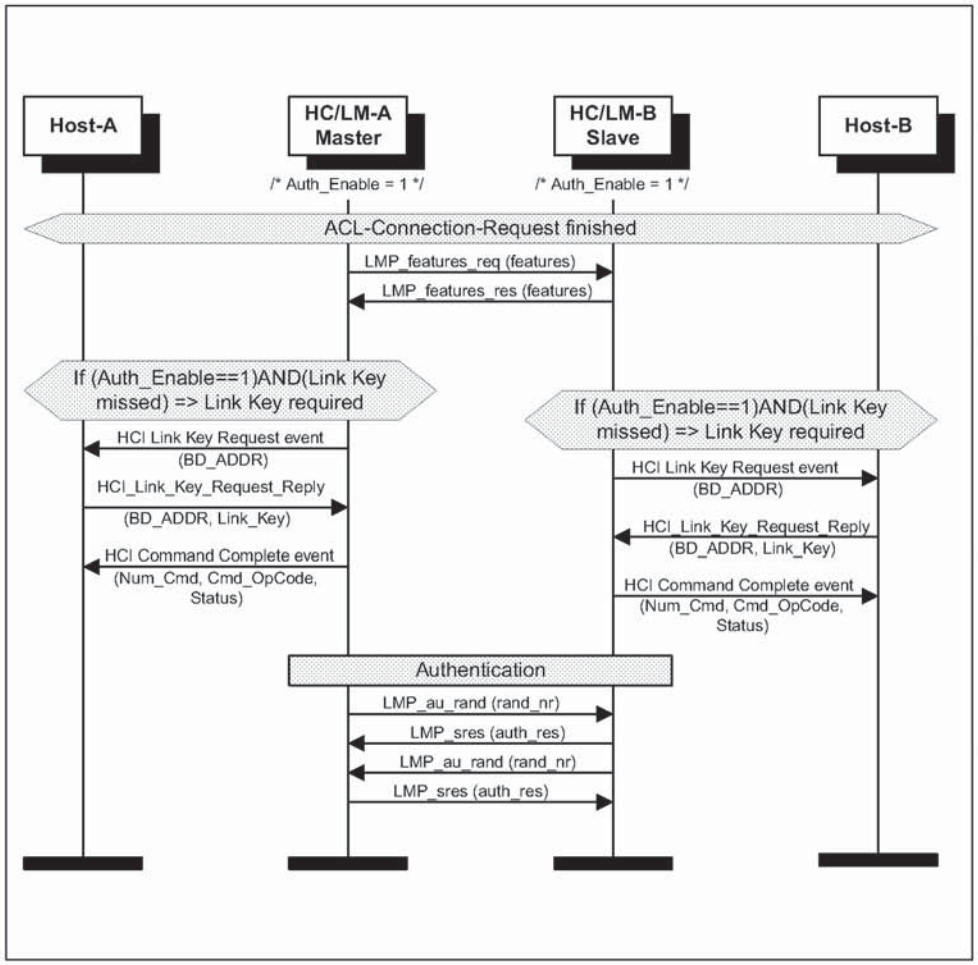


Figure 3.4: ACL Connection setup with authentication

3.3 ENCRYPTION AND CONNECTION SETUP COMPLETE

Once the pairing/authentication procedure is successful, the encryption procedure will be started. Here, the MSC only shows how to set up an encrypted point-to-point connection (Encryption_Mode = 1 /*point-to-point/). Note: an encrypted connection requires an established common link key.

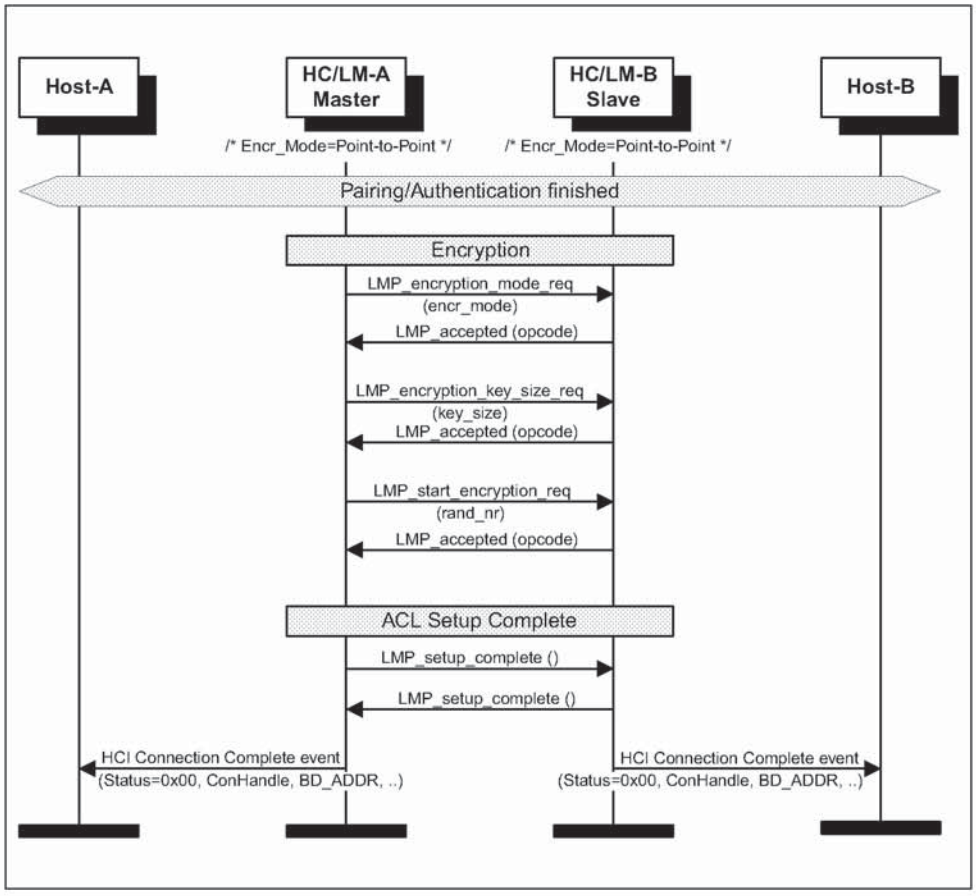


Figure 3.5: Encryption and Setup complete

3.4 ACL DISCONNECTION

At any time, an established ACL Connection can be detached by an HCI_Disconnect (Connection_Handle, Reason). If one or several SCO Connections exist, they must first be detached before the ACL Connection can be released.

Note: the disconnection procedure is one-sided and doesn't need an explicit acknowledgment from the remote LM. So the ARQ Acknowledgment from the LC is needed, to ensure that the remote LM has received the LMP_detach (reason).

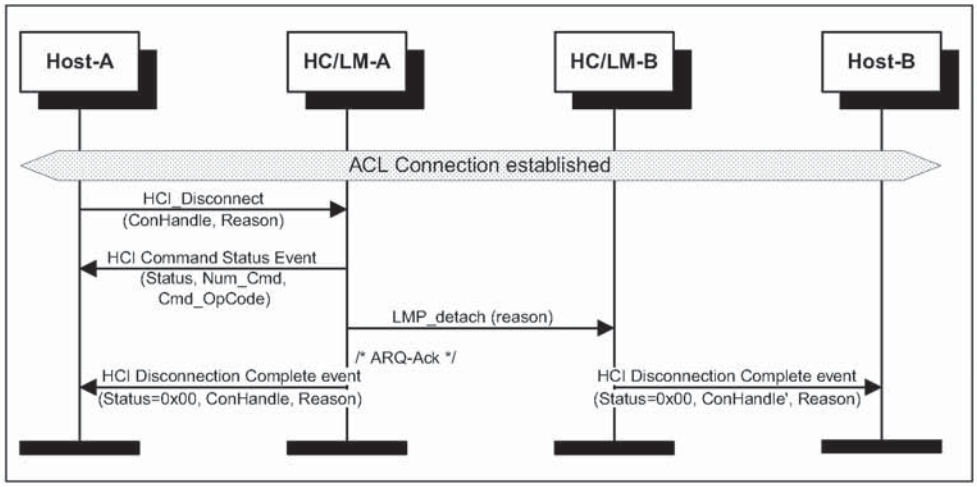


Figure 3.6: ACL Disconnection

4 OPTIONAL ACTIVITIES AFTER ACL CONNECTION ESTABLISHMENT

4.1 AUTHENTICATION REQUESTED

Authentication can be explicitly executed at any time after an ACL Connection has been established. If the Link Key was missed in HC/LM, the Link Key will be required from the Host, as in the authentication procedure (see 3.2.2).

Note: if the HC/LM and the Host don't have the Link Key a PIN Code Request event will be sent to the Host to request a PIN Code for pairing. A procedure identical to ACL Connection Setup with Pairing (see 3.2.1) will be used.

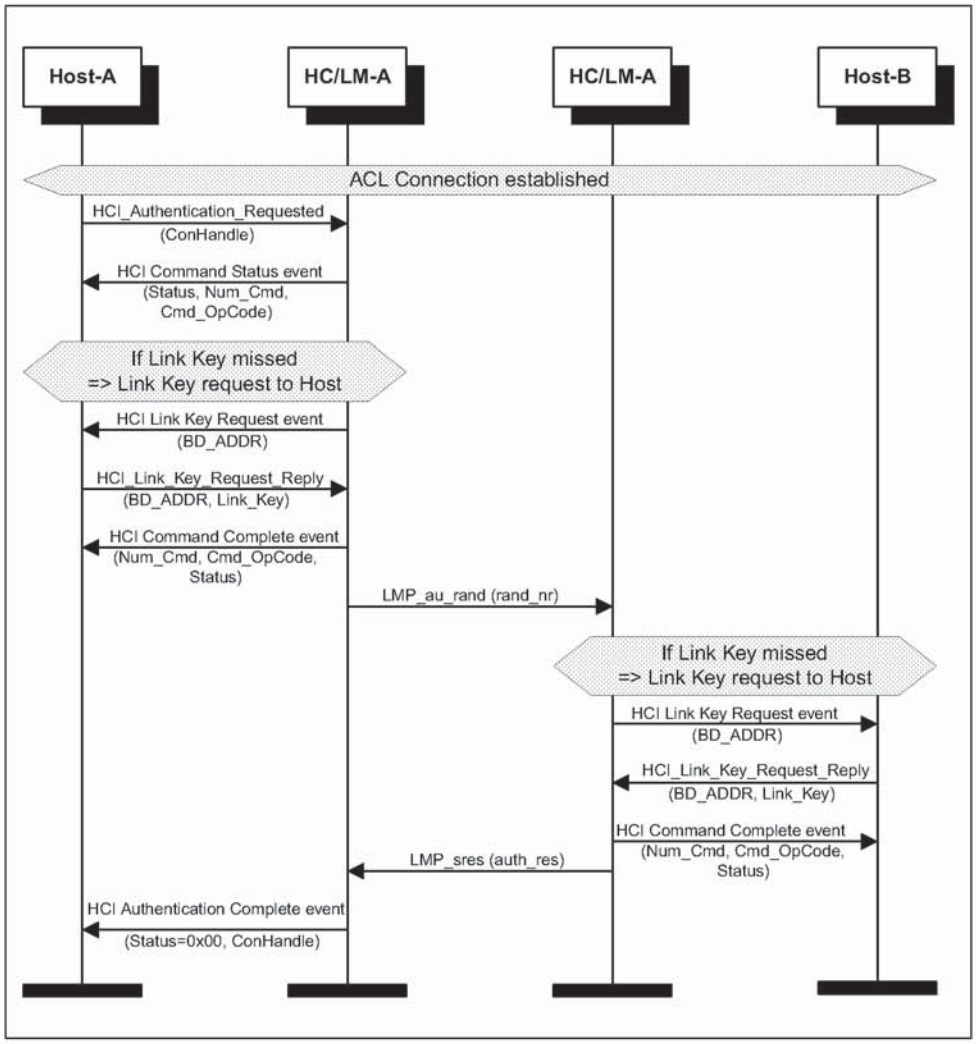


Figure 4.1: Authentication Requested

4.2 SET CONNECTION ENCRYPTION

Using the command HCI_Set_Connection_Encryption (Connection_Handle, Encryption_Enable), the Host is able to switch the encryption of a connection with the specified Connection_Handle to ON/OFF. This command can be applied on both the master- and slave sides (only the master side is shown in Figure 4.2 Set Connection Encryption). If this command occurs on the slave side, the only difference is that LMP_encryption_mode_req (encryption_mode) will be sent from the HC/LM Slave. LMP_encryption_key_size_req (key_size) and LMP_start_encryption_req (rand_nr) will still be requested from the HC/LM master.

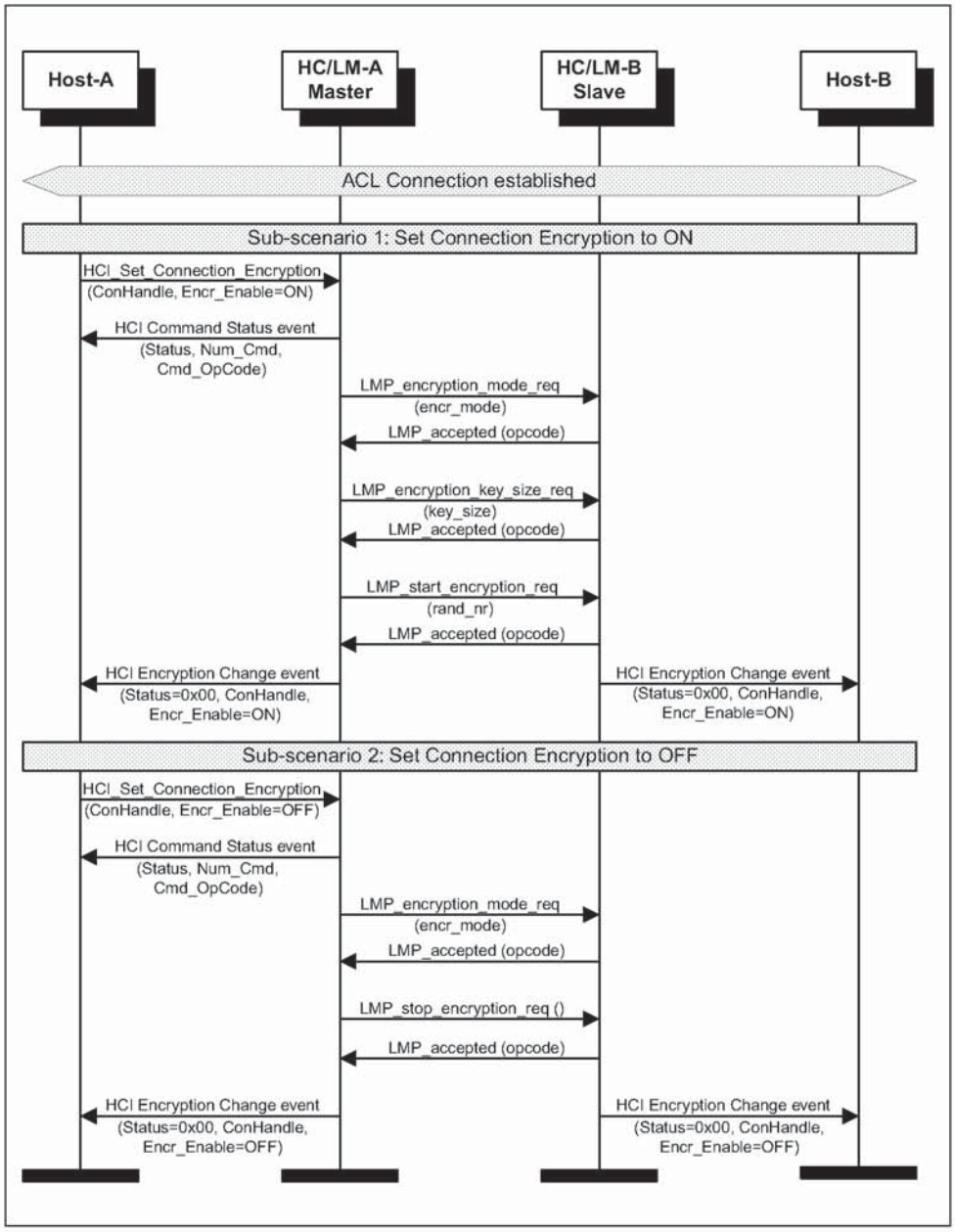


Figure 4.2: Set Connection Encryption

4.3 CHANGE CONNECTION LINK KEY

Using the command HCI_Change_Connection_Link_Key (Connection_Handle), the Host can explicitly change the common link key shared between the BT Devices.

Note: if the connection encryption was enabled and the temporary link key was used, it is the task of the BT Master to automatically restart the encryption (first stop and then restart) after the link key is successfully changed.

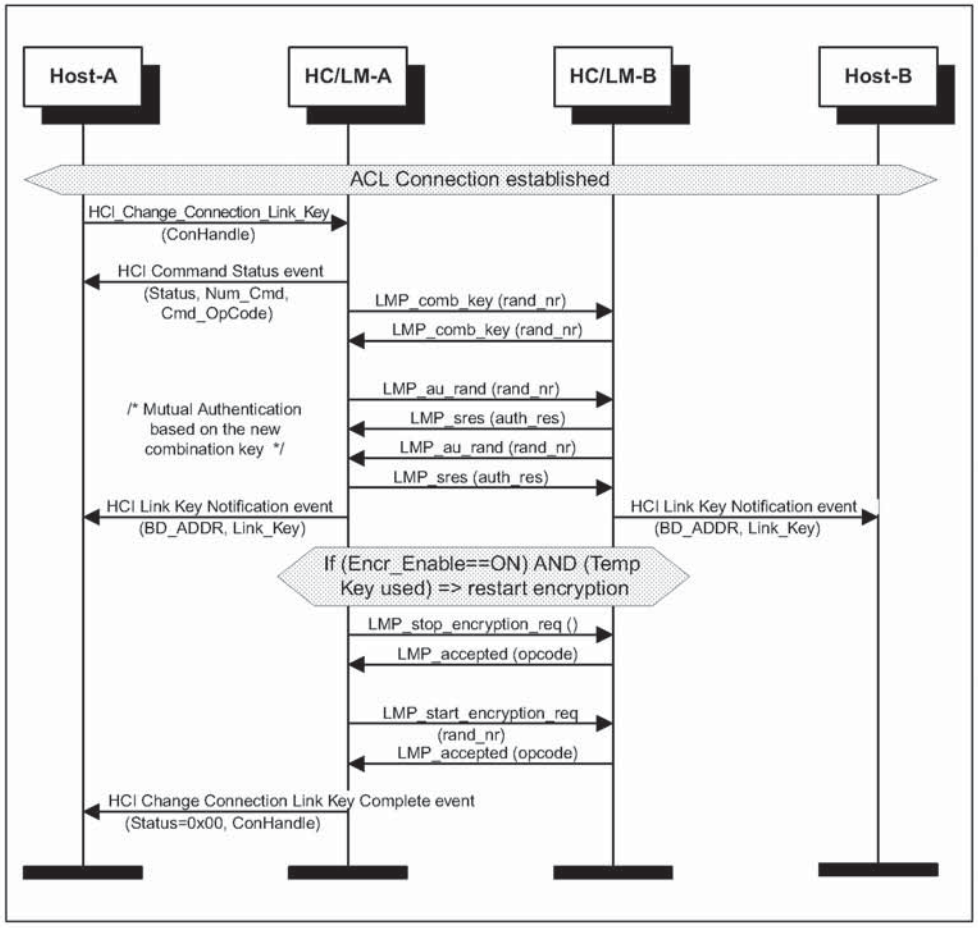


Figure 4.3: Change Connection Link Key

4.4 MASTER LINK KEY

The Figure 4.4 Master Link Key shows how the Host can explicitly switch between the temporary Link Key and the semi-permanent Link Key. Since this command can only be used for the BT Master, the Link Key switch will affect all connections.

Note: if encryption was enabled, it is the task of the BT Master to restart the encryption separately for each slave.

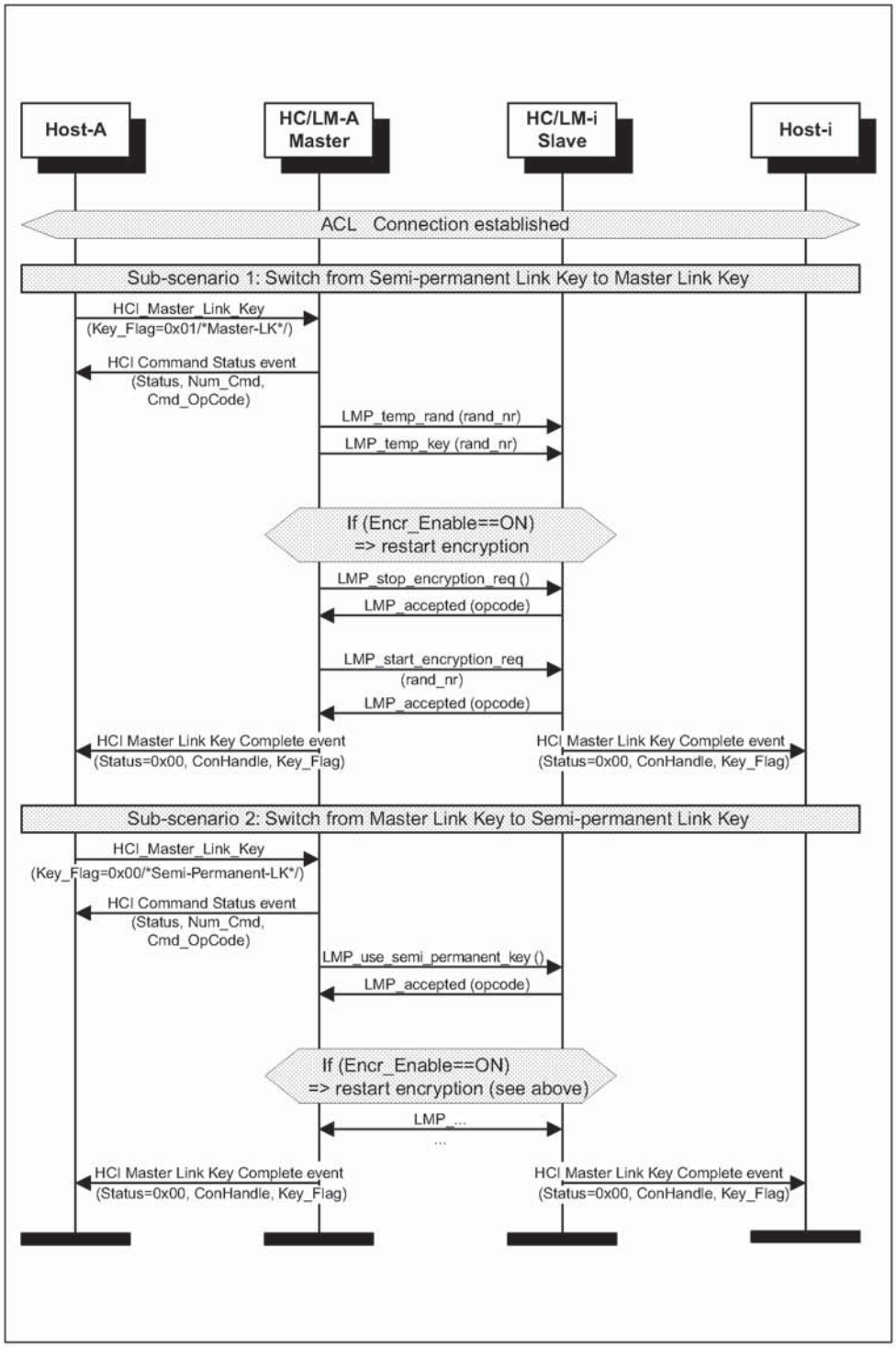


Figure 4.4: Master Link Key

4.5 READ REMOTE SUPPORTED FEATURES

Using the command HCI_Read_Remote_Supported_Features (Connection_Handle) the supported LMP Features of a remote BT Device can be read. These features contain supported packet types, supported modes, supported audio coding modes, etc.

Note: if the LMP Features was exchanged during ACL Connection Setup, the HC/LM A may return the Read Remote Supported Features Complete event (Status, Connection_Handle, LMP_Features) without exchange of LMP PDUs.

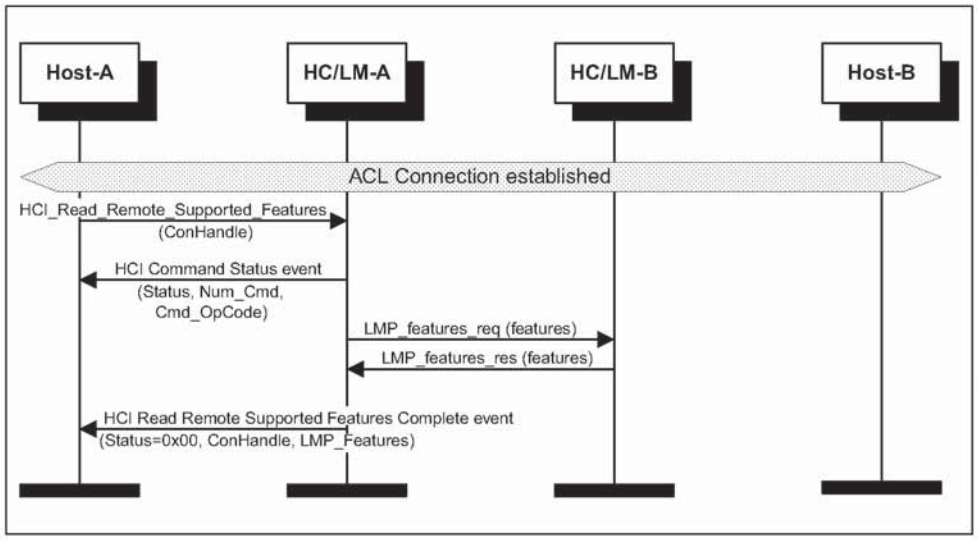


Figure 4.5: Read Remote Supported Features

4.6 READ CLOCK OFFSET

Using the command HCI_Read_Clock_Offset (Connection_Handle) the BT Master can read the Clock Offset of the BT Slaves. The Clock Offset can be used to speed up the paging procedure in a later connection attempt. If the command is requested from the slave device, the HC/LM Slave will directly return a Command Status event and an Read Clock Offset Complete event without exchange of LMP PDUs.

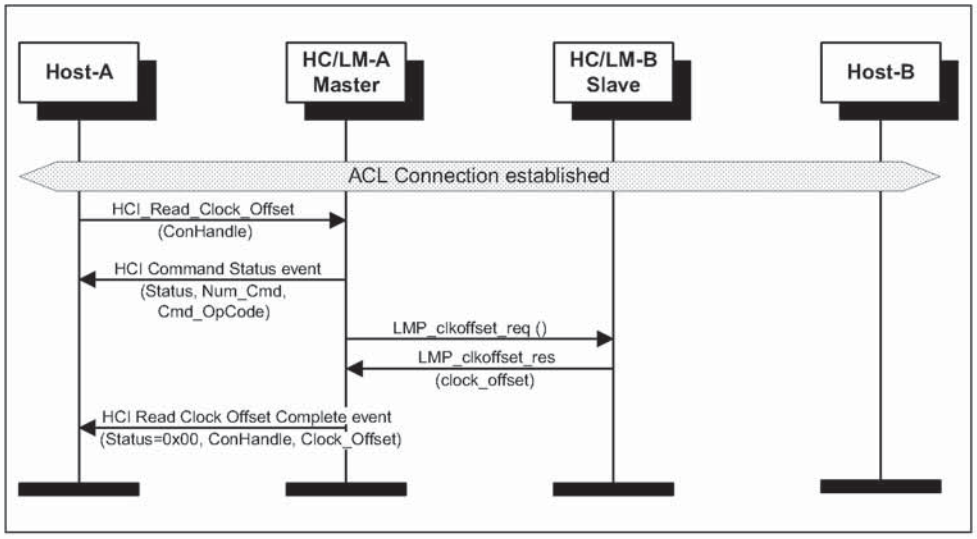


Figure 4.6: Read Clock Offset

4.7 READ REMOTE VERSION INFORMATION

Using HCI_Read_Remote_Version_Information (Connection_Handle) the version information consisting of LMP_Version, Manufacturer_Name and LMP_Subversion from the remote BT Device can be read.

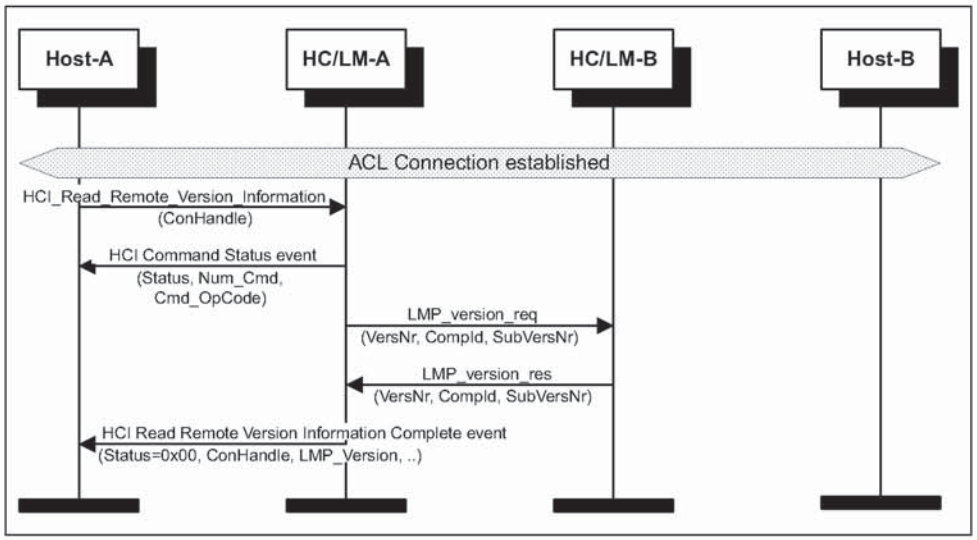


Figure 4.7: Read Remote Version Information

4.8 QOS SETUP

To set up the Quality of Service, the command HCI_QoS_Setup (Connection_Handle, Flags, Service_Type, Token_Rate, Peak_Bandwidth, Latency, Delay_Variation) is used.

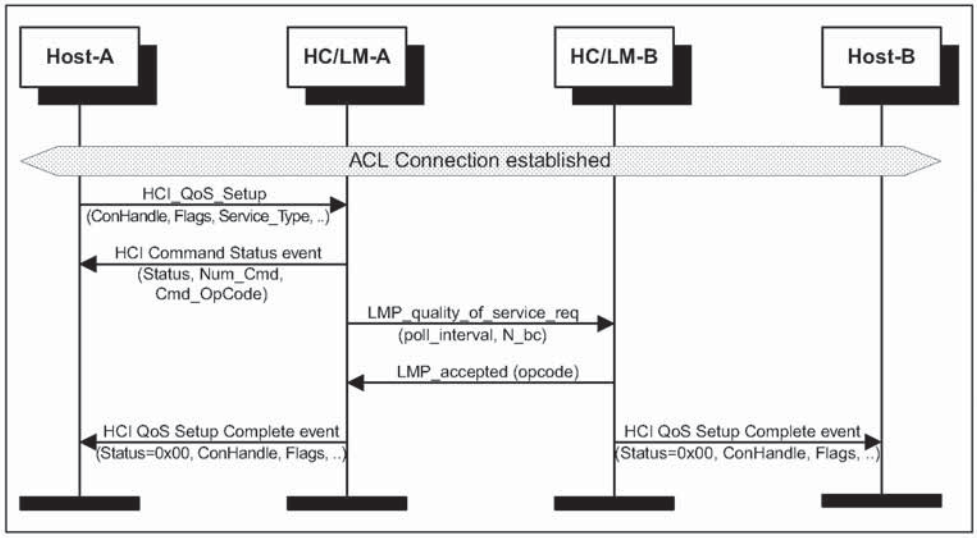


Figure 4.8: QoS Setup

4.9 SWITCH ROLE

The command HCI_Switch_Role (BD_ADDR, Role) can be used to explicitly switch the current role of the local BT Device for a particular connection with the specified BT Device (BD_ADDR). The local HC/LM has to check whether the switch is performed or not.

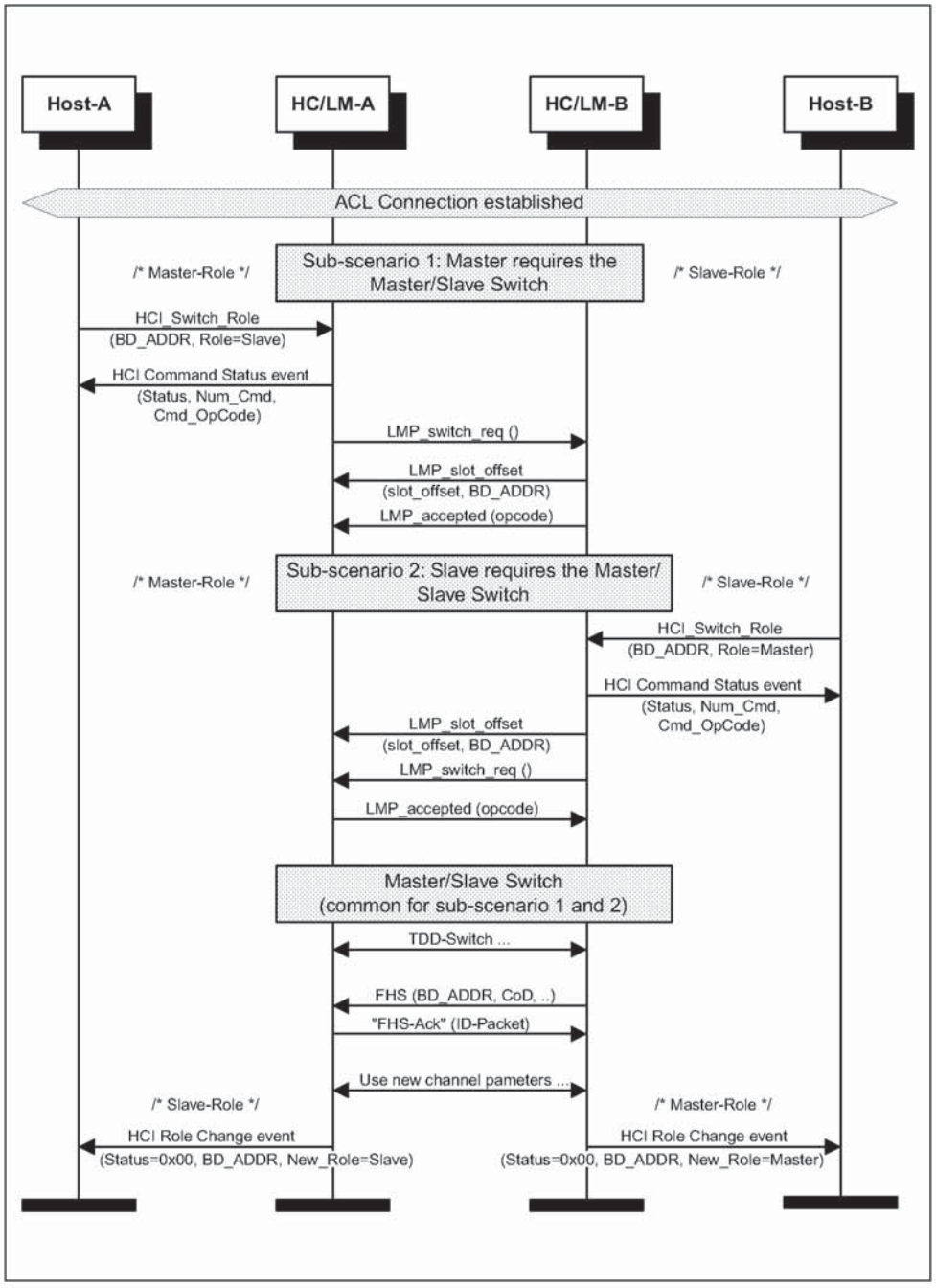


Figure 4.9: Switch Role

5 SCO CONNECTION ESTABLISHMENT AND DETACHMENT

5.1 SCO CONNECTION SETUP

SCO Connection setup requires an established ACL Connection. It is the task of the Host to create an ACL Connection first and then the SCO Link.

Note: On the slave side, an incoming connection request can be automatically accepted by using HCI_Set_Event_Filter (Filter_Type, Filter_Condition_Type, Condition) with the Filter_Type = 0x02 /*Connection_Setup*/. Furthermore, for each SCO Link to a BT Device, a separate SCO Connection Handle is needed.

5.1.1 Master activates the SCO Connection setup

To set up an SCO Connection, the HCI_Add_SCO_Connection (Connection_Handle, Packet_Type) command is used. The specified Connection_Handle is related to the ACL Connection that must have been created before the HCI_Add_SCO_Connection is issued.

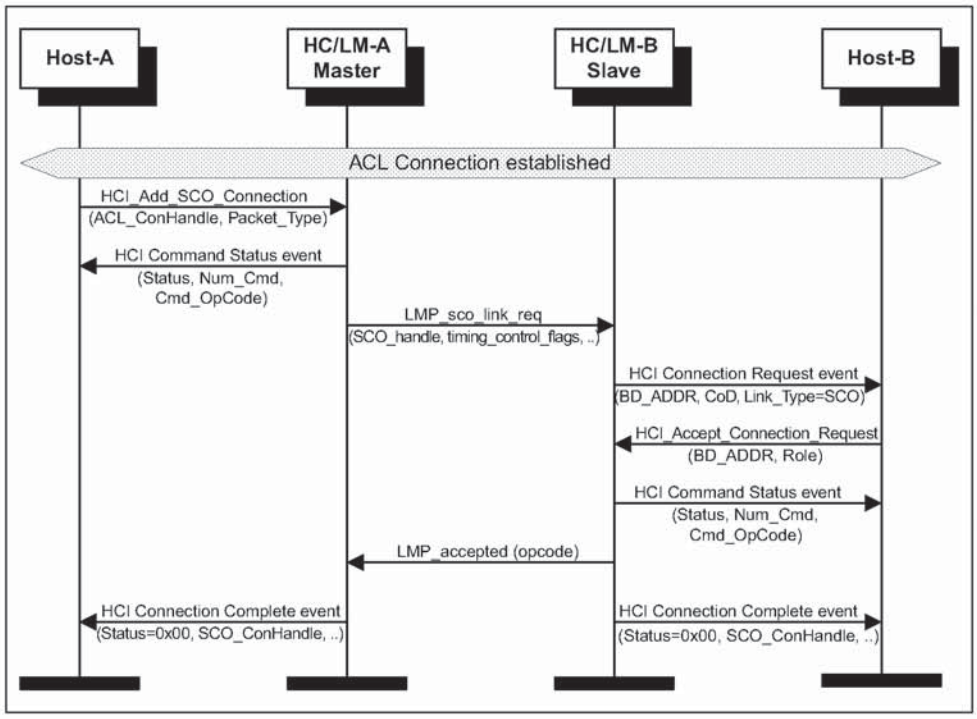


Figure 5.1: SCO Connection setup (activated from master)

5.1.2 Slave activates the SCO Connection setup

The same command HCI_Add_SCO_Connection (Connection_Handle, Packet_Type) can be used to create an SCO Link when the local BT Device is a BT Slave. Here the specified Connection_Handle belongs to the established ACL Connection between the BT Devices. Compared to 5.1.1, the only difference is that the HC/LM Slave starts the SCO Setup with LMP_sco_link_req first.

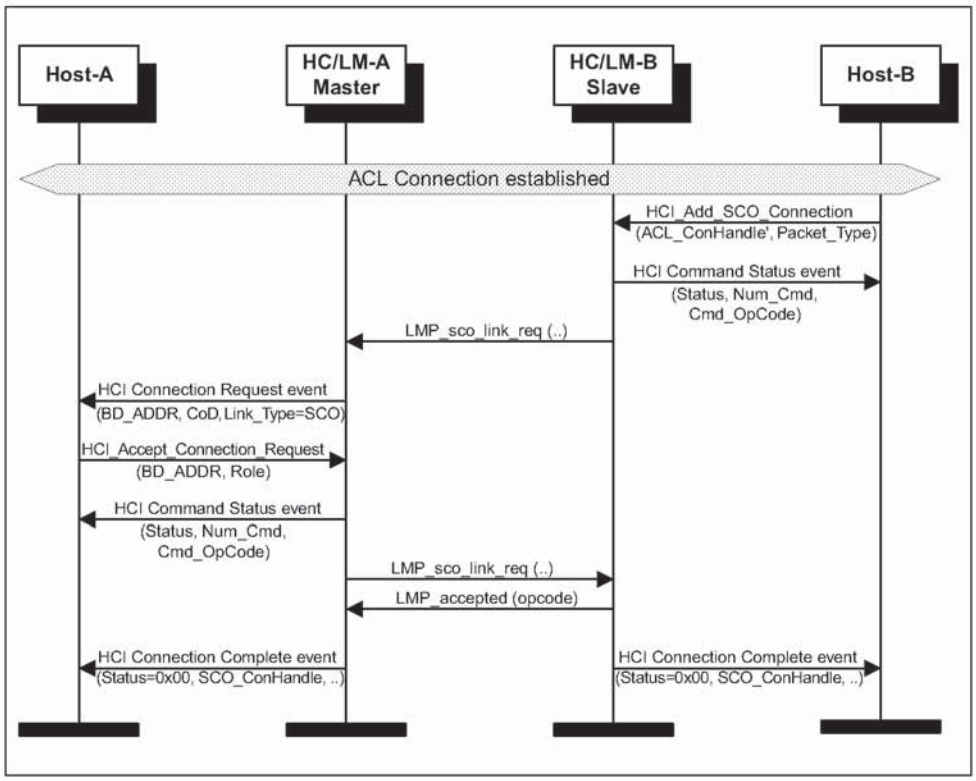


Figure 5.2: SCO Connection setup (activated from slave)

5.2 SCO DISCONNECTION

An established SCO Connection can be detached at any time. Since several SCO Connections can exist between a BT Master and a BT Slave, an SCO Disconnection only removes the SCO Link with the specified SCO Connection Handle. The other SCO Connections will still exist.

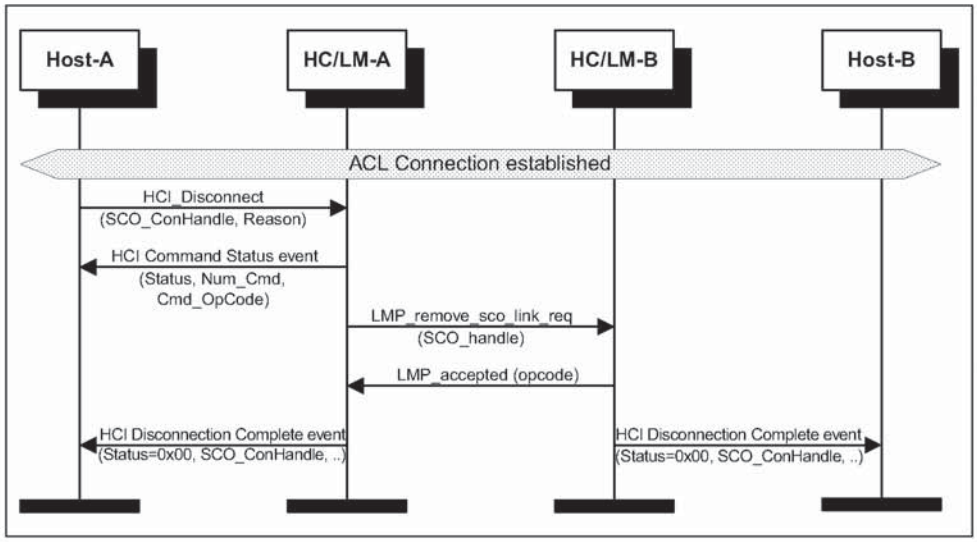


Figure 5.3: SCO Disconnection

6 SPECIAL MODES: SNIFF, HOLD, PARK

Entry into sniff, hold or park mode requires an established ACL Connection. The following table summarizes the modes and the BT Role that can request, force, activate or exit the modes.

	Sniff	Hold	Park
Request	Master/Slave	Master/Slave	Master/Slave
Force	Master	Master/Slave	Master
Activation	Master	Master/Slave	Master
Release	Master/Slave	Automatic	Master/Slave

Table 6.1: Summary of modes (Sniff, Hold, Park)

6.1 SNIFF MODE

Sniff Mode is used when a slave shall participate in the piconet only in a sniff interval. For the Sniff Mode negotiation, the Host specifies the Sniff_Max_Interval and the Sniff_Min_Interval so that HC/LM will be able to choose the one sniff interval in this range. The used command is HCI_Sniff_Mode (Connection_Handle, Sniff_Max_Interval, Sniff_Min_Interval, Sniff_Attempt, Sniff_Timeout).
Since Sniff Mode is a periodic mode, the command HCI_Exit_Sniff_Mode (Connection_Handle) is needed to return to Active Mode.

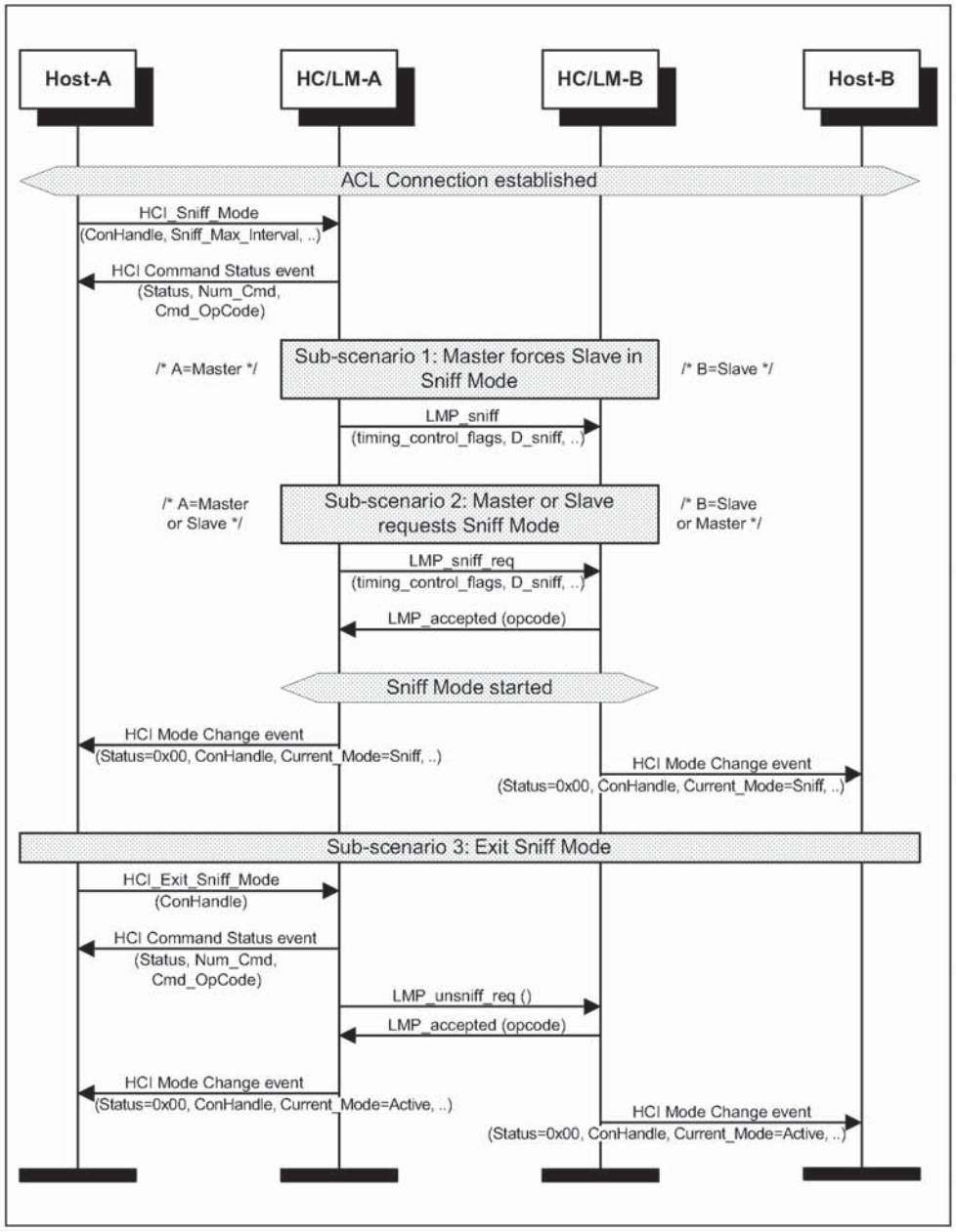


Figure 6.1: Sniff Mode

6.2 HOLD MODE

Hold Mode is useful when a BT Device doesn't want to participate in the connection for a Hold Mode Length. Using the command HCI_Hold_Mode (Connection_Handle, Hold_Max_Length, Hold_Min_Length), the Host specifies the Hold_Max_Length and Hold_Min_Length. The HC/LM will then be able to negotiate a Hold Mode Length in this range. When the hold mode is started

or complete, Mode Change event (Status, Connection_ Handle, Current_Mode, Interval) will be used to inform the Host about the actual mode.

Note: the Hold Mode is exited when the Hold Mode Length has expired, so it is no guarantee that the remote BT Device is immediately active.

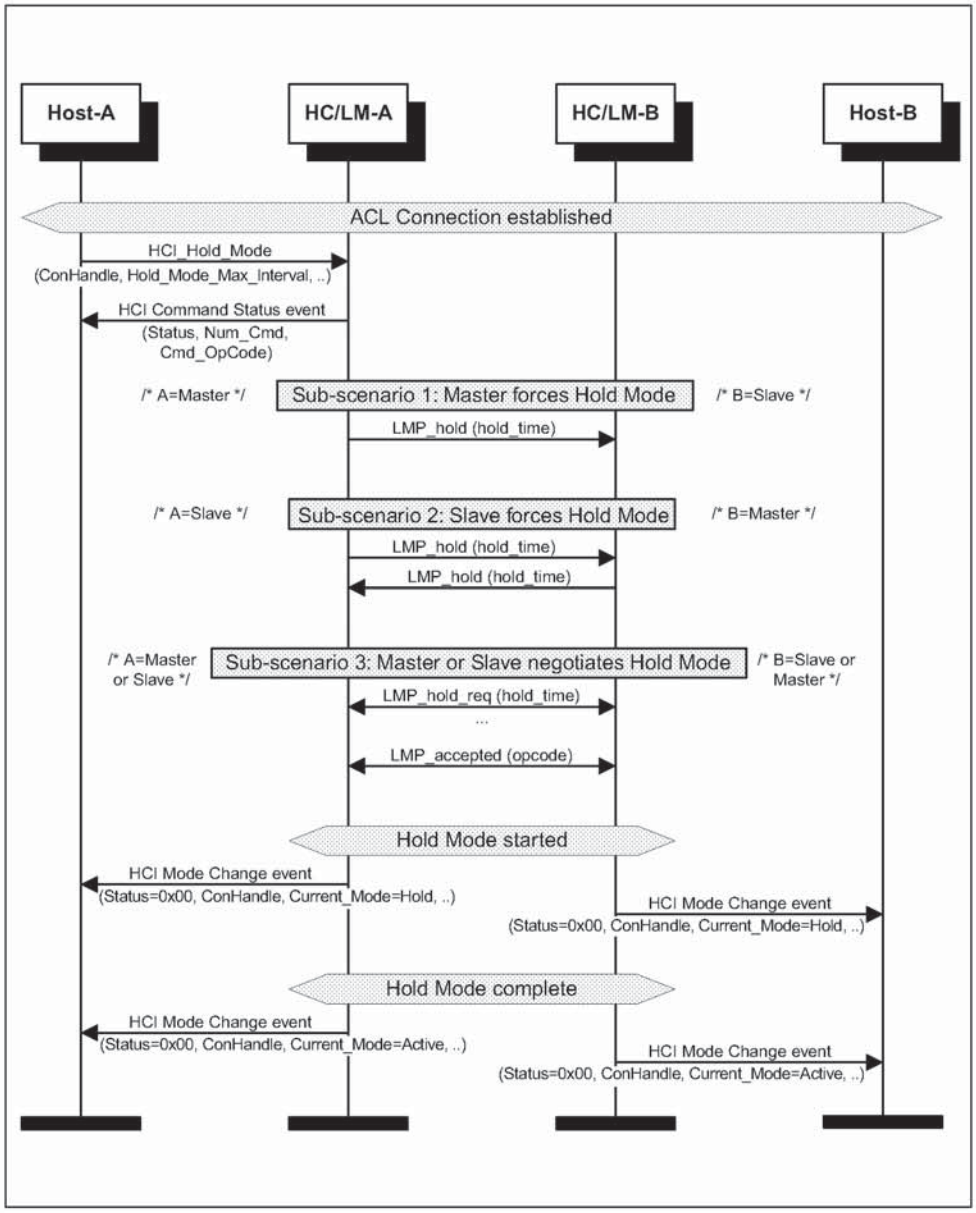


Figure 6.2: Hold Mode

6.3 PARK MODE

Park Mode is used to render the slaves inactive but still synchronized to the master using the beacon interval. In park mode, broadcast is performed.

6.3.1 Enter park mode

Using the command HCI_Park_Mode (Connection_Handle, Beacon_Max_Interval, Beacon_Min_Interval) the Host specifies the Beacon_Max_Interval and Beacon_Min_Interval so that HC/LM can set up a Beacon-Interval in this range for the BT Slaves. In Park Mode, the BT Slave gives up its AM_ADDR.

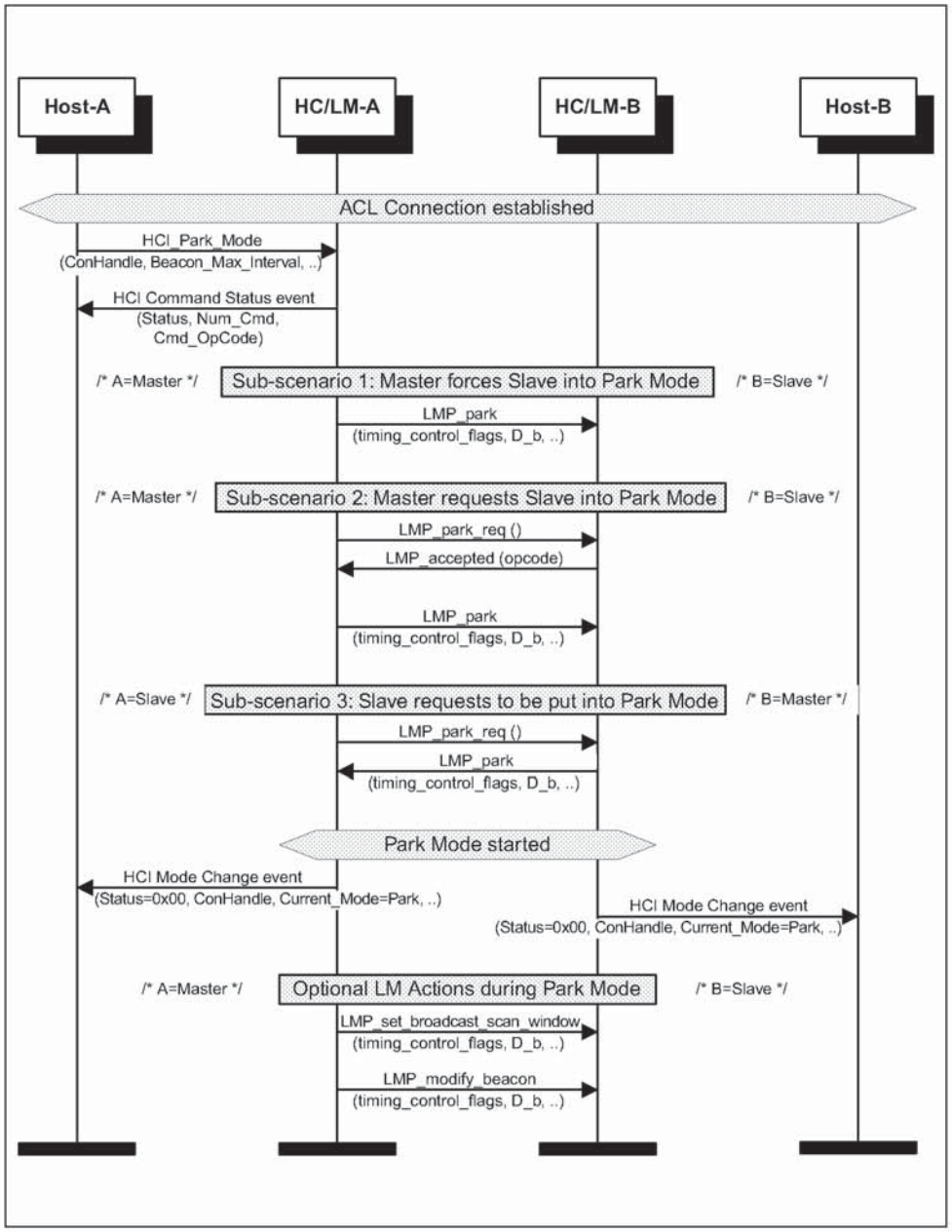


Figure 6.3: Enter Park Mode

6.3.2 Exit Park Mode

Since Park Mode is a periodic mode, the command HCI_Exit_Park_Mode (Connection_Handle) will be used to return to Active Mode. A parked BT Slave can send an Access_Request_Message to request to leave the Park Mode. It is the task of master HC/LM to use LMP_unpark_PM_ADDR_req (..) or LMP_unpark_BD_ADDR_req (..) to unpark a BT Slave.

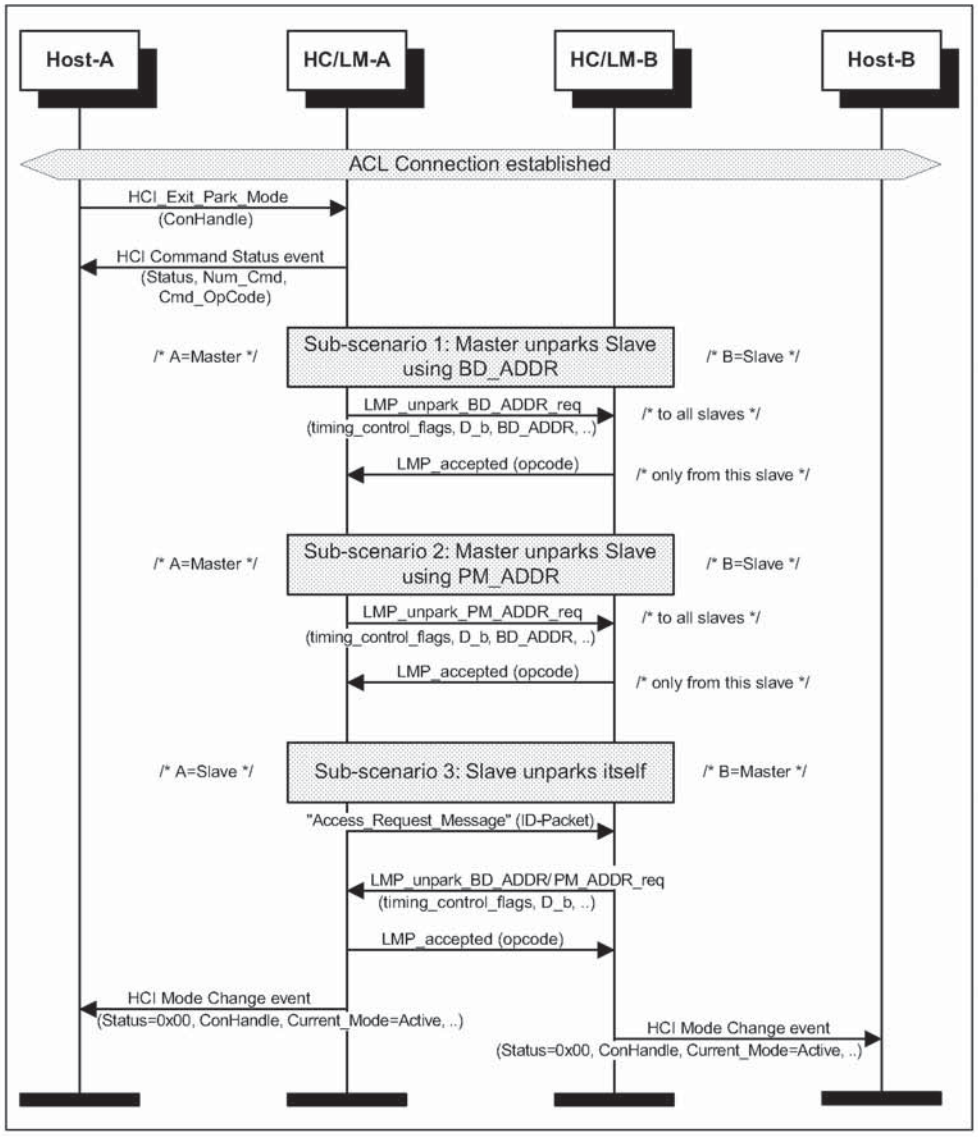


Figure 6.4: Exit Park Mode

7 BUFFER MANAGEMENT, FLOW CONTROL

The HC Data buffers are configured by the HC and managed by the Host. On initialization, the Host will issue HCI_Read_Buffer_Size. This specifies the maximum allowed length of HCI data packets sent from the Host to the HC, and the maximum number of ACL and SCO data packets that the HC can store in its buffer. After a connection is created, HC will frequently inform the Host about the number of sent packets using Number Of Completed Packets event (Number_of_Handles, Connection_Handle[I], HC_Num_Of_ Completed_Packets[i]) (see Figure 7.1 Host-to-HC flow control).

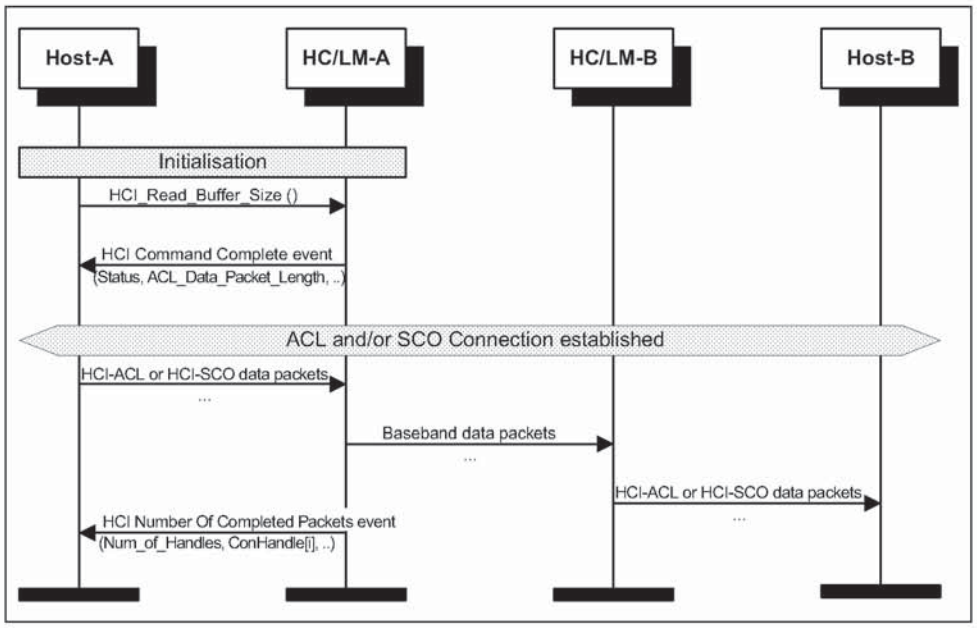


Figure 7.1: Host to HC flow control

Accordingly the HC to Host flow control can be applied in the same way so that during initialization the Host configures the Buffer Size and later the Host Controller will manage the Host Buffers.
Using HCI_Set_Host_Controller_To_Host_Flow_Control (Flow_Control_Enable) the Host can decide to apply the HC to Host flow control or not. For flow control itself HCI_Host_Buffer_Size (Host_ACL_Data_Packet_Length, Host_SCO_Data_Packet_Length, Host_Total_Num_ACL_Data_Packets, Host_Total_Num_SCO_Data_Packets) and HCI_Host_Number_Of_Completed_Packets (Number_of_Handles, Connection_Handle[I], Host_Num_Of_Completed_Packets[I]) will be used (for details see Figure 7.2 HC to Host Flow Control).

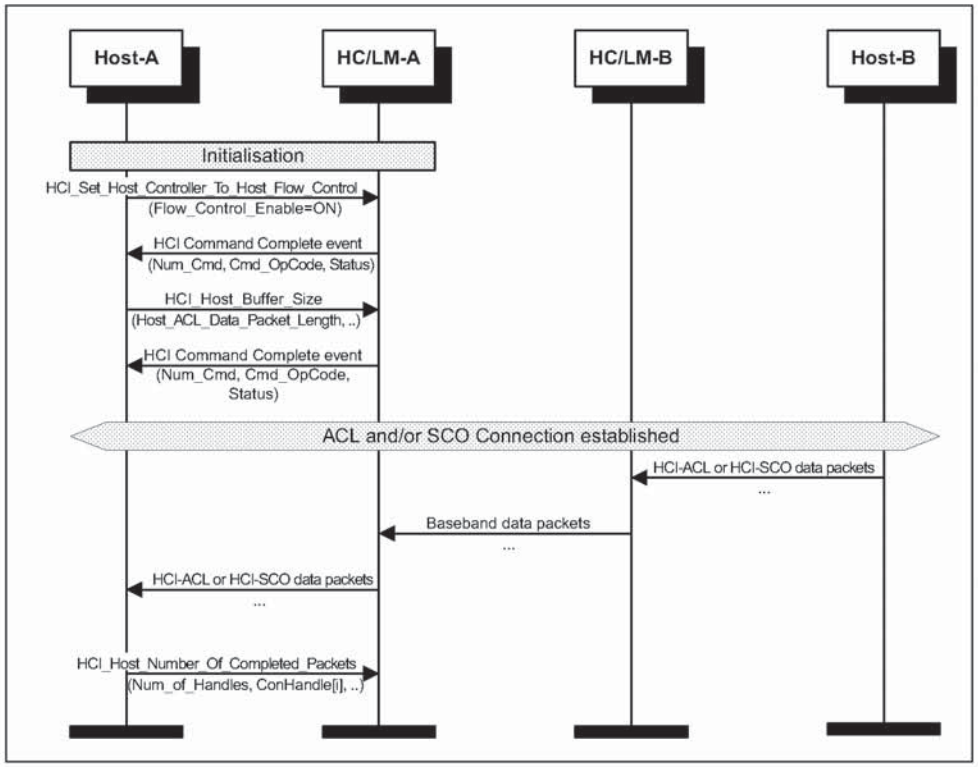


Figure 7.2: HC to Host Flow Control

8 LOOPBACK MODE

8.1 LOCAL LOOPBACK MODE

The local Loopback Mode is used to loopback received HCI Commands, and HCI ACL and HCI SCO packets sent from the Host.

The HC will send four Connection Complete events (one for ACL, three for SCO Connections) so that the Host can use the Connection_Handles to re-send HCI ACL and HCI SCO Packet to HC. To exit the local Loopback Mode, HCI_Write_Loopback_Mode (Loopback_Mode=0x00) or HCI_Reset ( ) will be used.

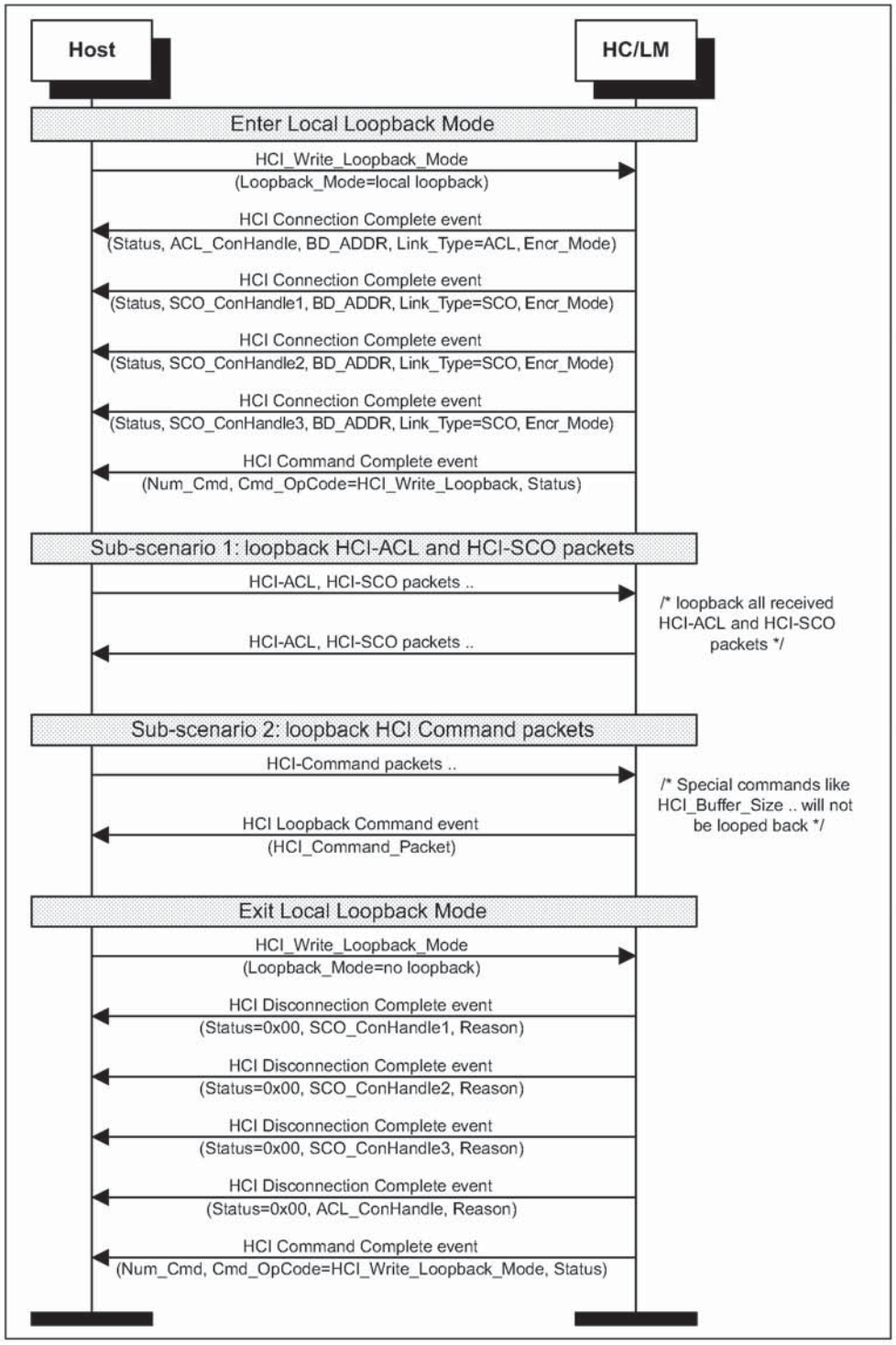


Figure 8.1: Local Loopback Mode

8.2 REMOTE LOOPBACK MODE

The remote Loopback Mode is used to loopback all received Baseband ACL and SCO Data received from a remote BT Device. During remote Loopback Mode, ACL and SCO Connection can be created. The remote Loopback Mode can be released with the command HCI_Write_Loopback_Mode (Loopback_Mode=0x00).

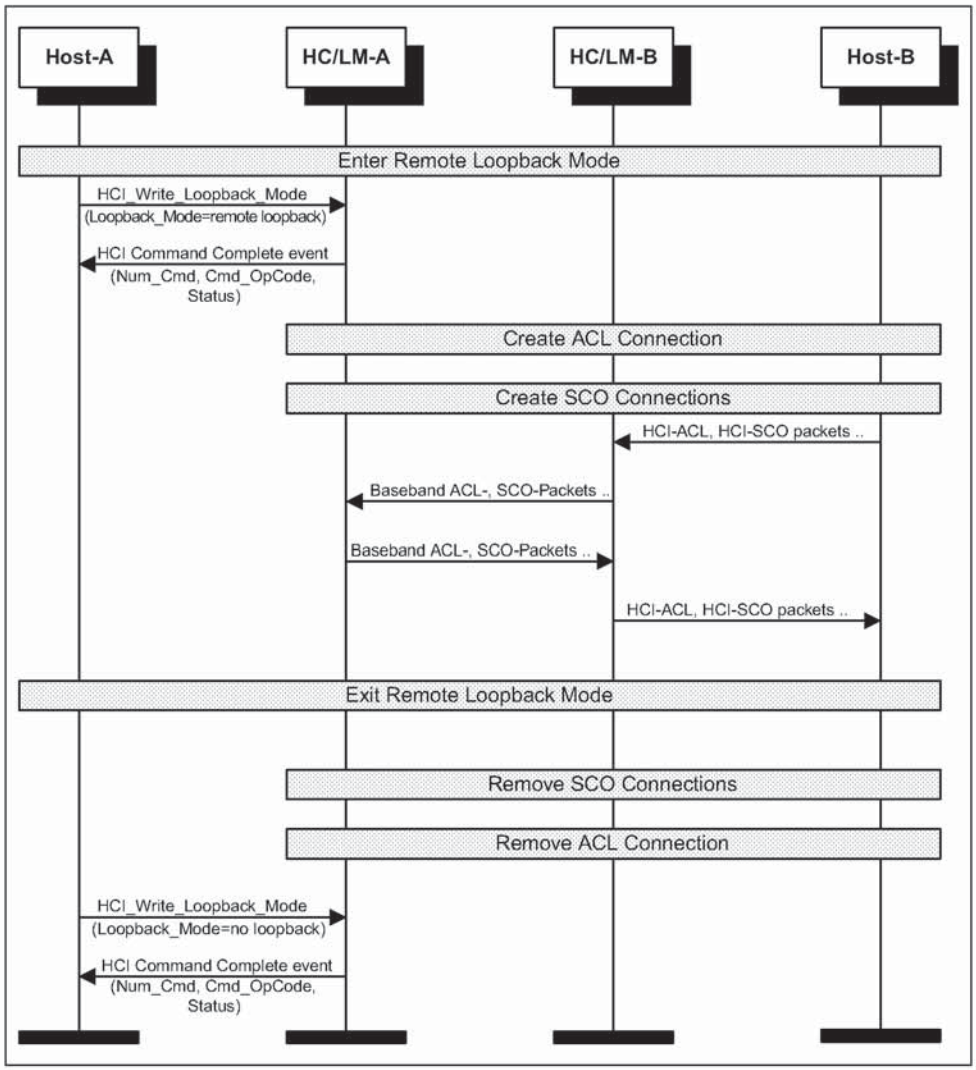


Figure 8.2: Remote Loopback Mode

9 LIST OF ACRONYMS AND ABBREVIATIONS

BT	Bluetooth
HC	Host Controller
HCI	Host Controller Interface
LAP	Lower Address Part
LC	Link Controller
LM	Link Manager
LMP	Link Manager Protocol
MSC	Message Sequence Chart
PDU	Protocol Data Unit

10 LIST OF FIGURES

11 LIST OF TABLES

12 REFERENCES

[1] "Baseband Specification" on page 33

[2] "Link Manager Protocol" on page 185

[3] "Host Controller Interface Functional Specification" on page 517

[4] "Logical Link Control and Adaptation Protocol Specification" on page 245

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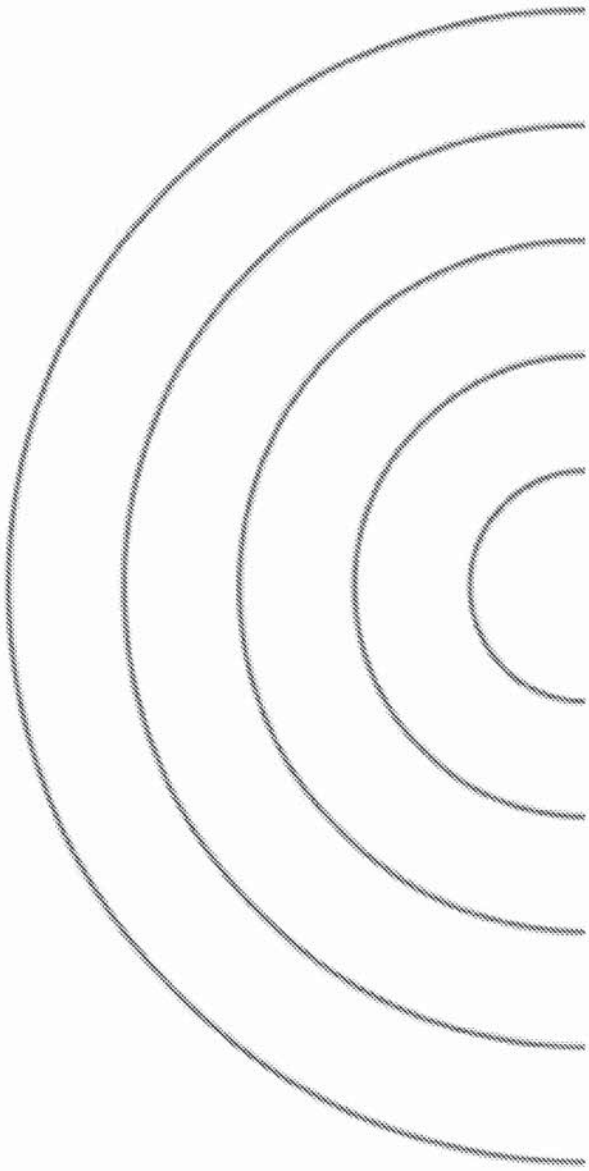
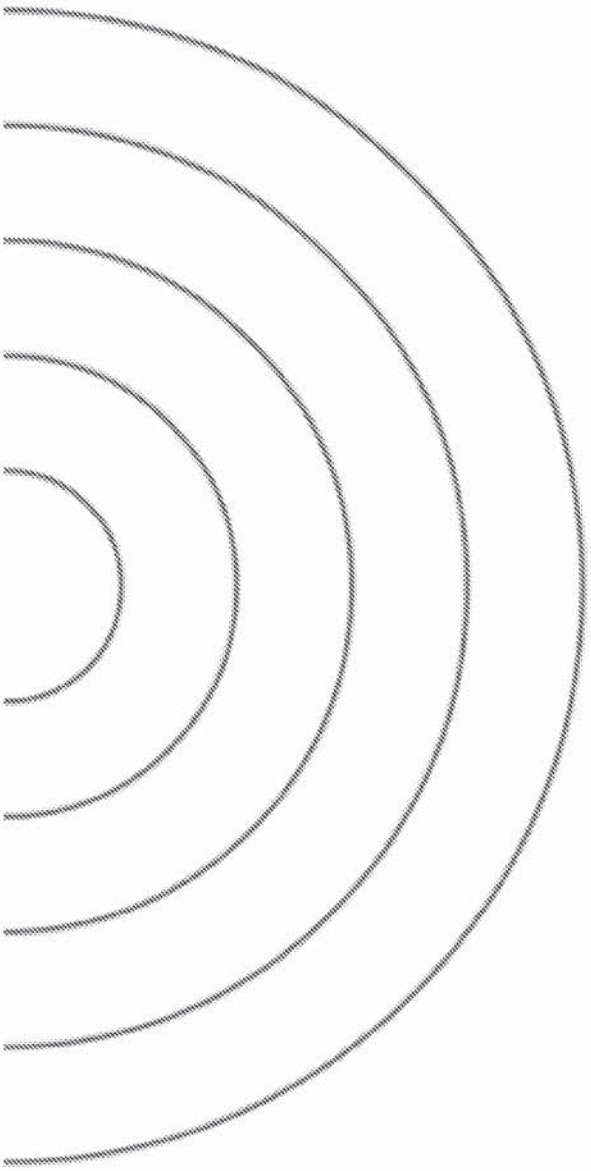


Specification Volume 2

Specification of the Bluetooth System



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December 1st 1999

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Profiles of the Bluetooth System

Version 1.0B

Revision History

The Revision History is shown in Appendix I on page 413

Contributors

The persons who contributed to this specification are listed in Appendix II on page 421.

Web Site

This specification can also be found on the Bluetooth web site:
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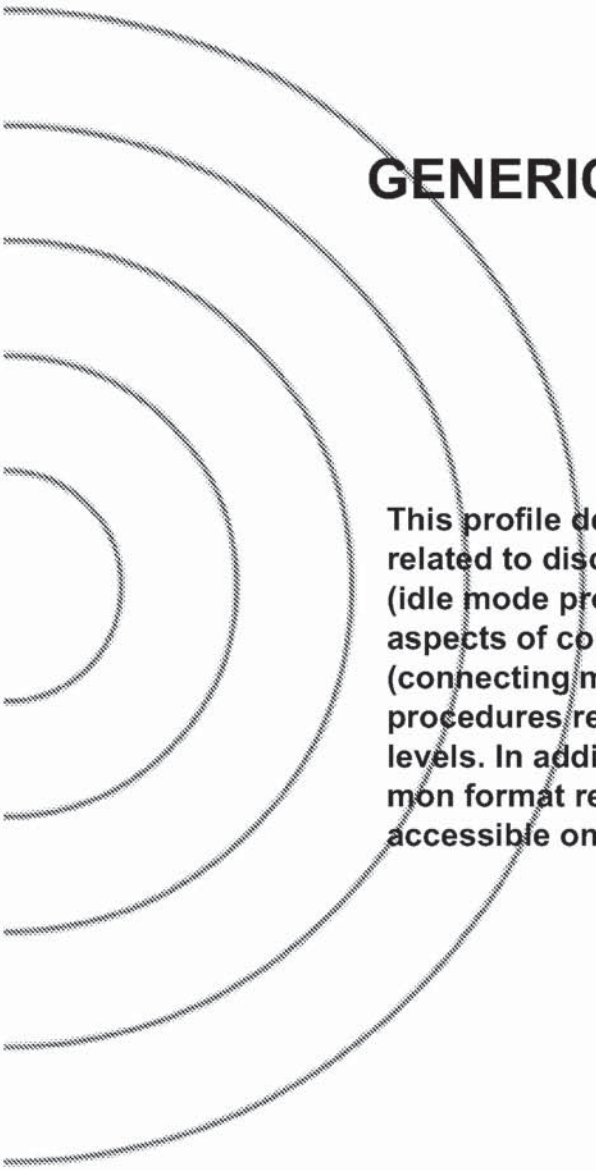
GENERIC ACCESS PROFILE



This profile defines the generic procedures related to discovery of Bluetooth devices (idle mode procedures) and link management aspects of connecting to Bluetooth devices (connecting mode procedures). It also defines procedures related to use of different security levels. In addition, this profile includes common format requirements for parameters accessible on the user interface level.

CONTENTS

FOREWORD

Interoperability between devices from different manufacturers is provided for a specific service and use case, if the devices conform to a Bluetooth SIG-defined profile specification. A profile defines a selection of messages and procedures (generally termed *capabilities*) from the Bluetooth SIG specifications and gives an unambiguous description of the air interface for specified service(s) and use case(s).

All defined features are process-mandatory. This means that, if a feature is used, it is used in a specified manner. Whether the provision of a feature is mandatory or optional is stated separately for both sides of the Bluetooth air interface.

1 INTRODUCTION

1.1 SCOPE

The purpose of the Generic Access Profile is:

To introduce definitions, recommendations and common requirements related to modes and access procedures that are to be used by transport and application profiles.

To describe how devices are to behave in standby and connecting states in order to guarantee that links and channels always can be established between Bluetooth devices, and that multi-profile operation is possible. Special focus is put on discovery, link establishment and security procedures.

To state requirements on user interface aspects, mainly coding schemes and names of procedures and parameters, that are needed to guarantee a satisfactory user experience.

1.2 SYMBOLS AND CONVENTIONS

1.2.1 Requirement status symbols

In this document (especially in the profile requirements tables), the following symbols are used:

'M' for mandatory to support (used for capabilities that shall be used in the profile);

'O' for optional to support (used for capabilities that can be used in the profile);

'C' for conditional support (used for capabilities that shall be used in case a certain other capability is supported);

'X' for excluded (used for capabilities that may be supported by the unit but shall never be used in the profile);

'N/A' for not applicable (in the given context it is impossible to use this capability).

Some excluded capabilities are capabilities that, according to the relevant Bluetooth specification, are mandatory. These are features that may degrade operation of devices following this profile. Therefore, these features shall never be activated while a unit is operating as a unit within this profile.

In this specification, the word *shall* is used for mandatory requirements, the word *should* is used to express recommendations and the word *may* is used for options.

1.2.2 Signalling diagram conventions

The following arrows are used in diagrams describing procedures :

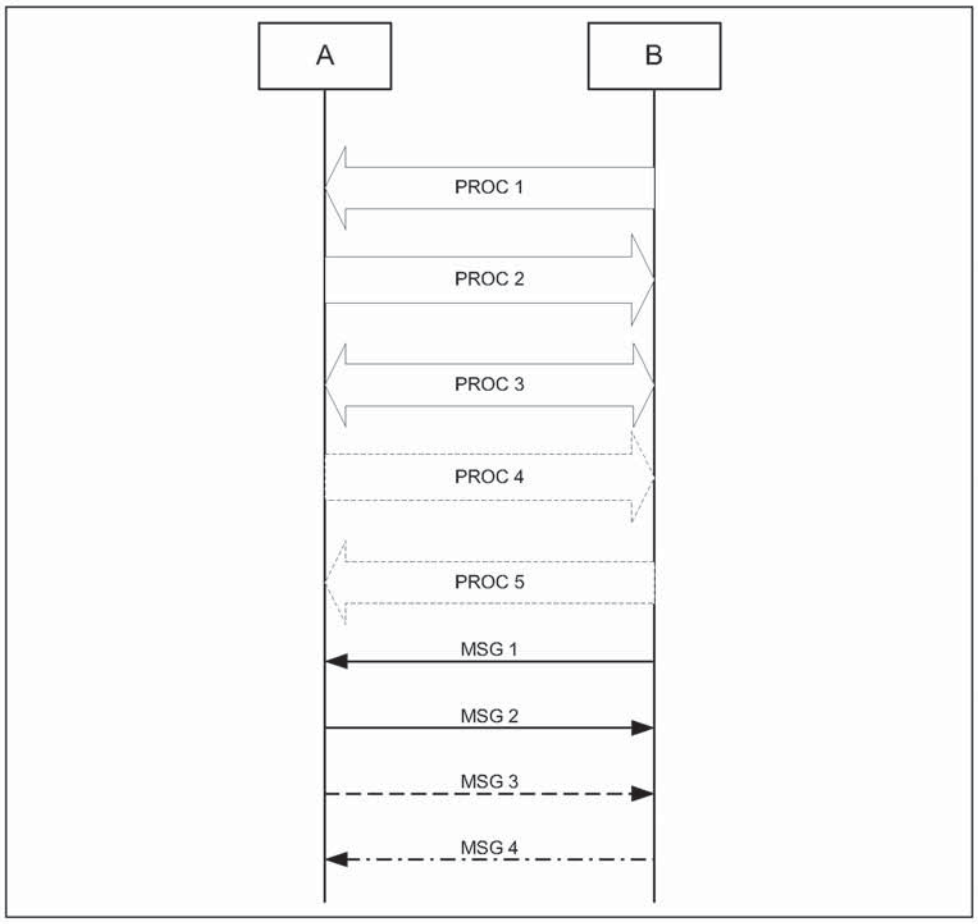


Figure 1.1: Arrows used in signalling diagrams

In the table above, the following cases are shown: PROC1 is a sub-procedure initiated by B. PROC2 is a sub-procedure initiated by A. PROC3 is a sub-procedure where the initiating side is undefined (may be both A or B). Dashed arrows denote optional steps. PROC4 indicates an optional sub-procedure initiated by A, and PROC5 indicates an optional sub-procedure initiated by B.

MSG1 is a message sent from B to A. MSG2 is a message sent from A to B. MSG3 indicates an optional message from A to B, and MSG4 indicates a conditional message from B to A.

1.2.3 Notation for timers and counters

Timers are introduced specific to this profile. To distinguish them from timers used in the Bluetooth protocol specifications and other profiles, these timers are named in the following format: '$T_{GAP}(nnn)$'.

2 PROFILE OVERVIEW

2.1 PROFILE STACK

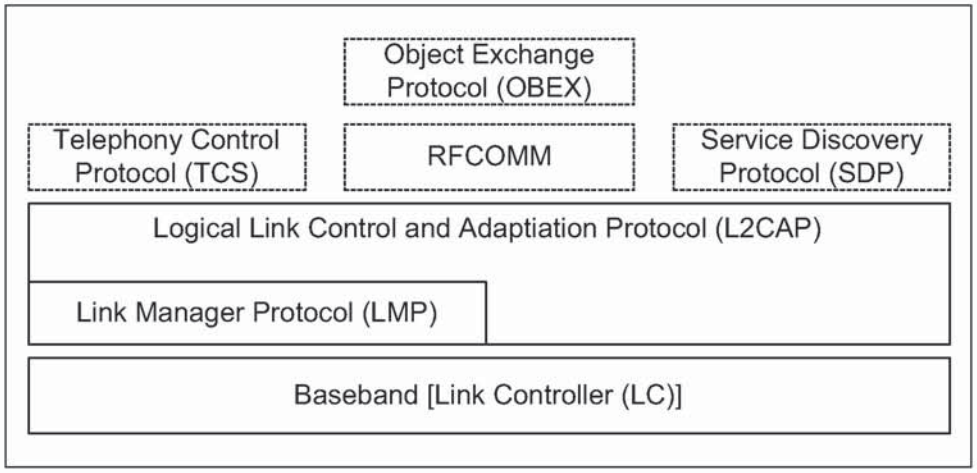


Figure 2.1: Profile stack covered by this profile.

The main purpose of this profile is to describe the use of the lower layers of the Bluetooth protocol stack (LC and LMP). To describe security related alternatives, also higher layers (L2CAP, RFCOMM and OBEX) are included.

2.2 CONFIGURATIONS AND ROLES

For the descriptions in this profile of the roles that the two devices involved in a Bluetooth communication can take, the generic notation of the A-party (the *paging device* in case of link establishment, or *initiator* in case of another procedure on an established link) and the B-party (*paged device* or *acceptor*) is used. The A-party is the one that, for a given procedure, initiates the establishment of the physical link or initiates a transaction on an existing link.

This profile handles the procedures between two devices related to discovery and connecting (link and connection establishment) for the case where none of the two devices has any link established as well as the case where (at least) one device has a link established (possibly to a third device) before starting the described procedure.

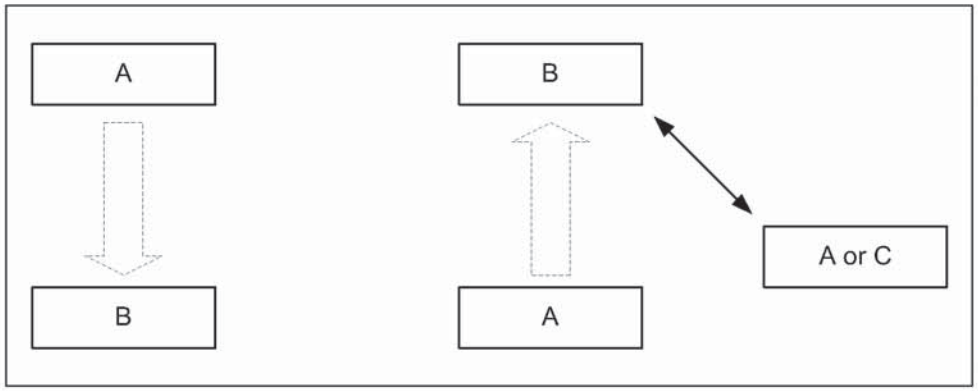


Figure 2.2: This profile covers procedures initiated by one device (A) towards another device (B) that may or may not have an existing Bluetooth link active.

The initiator and the acceptor generally operate the generic procedures according to this profile or another profile referring to this profile. If the acceptor operates according to several profiles simultaneously, this profile describes generic mechanisms for how to handle this.

2.3 USER REQUIREMENTS AND SCENARIOS

The Bluetooth user should in principle be able to connect a Bluetooth device to any other Bluetooth device. Even if the two connected devices don't share any common application, it should be possible for the user to find this out using basic Bluetooth capabilities. When the two devices do share the same application but are from different manufacturers, the ability to connect them should not be blocked just because manufacturers choose to call basic Bluetooth capabilities by different names on the user interface level or implement basic procedures to be executed in different orders.

2.4 PROFILE FUNDAMENTALS

This profile states the requirements on names, values and coding schemes used for names of parameters and procedures experienced on the user interface level.

This profile defines modes of operation that are not service- or profile-specific, but that are generic and can be used by profiles referring to this profile, and by devices implementing multiple profiles.

This profile defines the general procedures that can be used for discovering identities, names and basic capabilities of other Bluetooth devices that are in a mode where they can be discoverable. Only procedures where no channel or connection establishment is used are specified.

This profile defines the general procedure for how to create bonds (i.e. dedicated exchange of link keys) between Bluetooth devices.

This profile describes the general procedures that can be used for establishing connections to other Bluetooth devices that are in mode that allows them to accept connections and service requests.

2.5 CONFORMANCE

Bluetooth devices that do not conform to any other Bluetooth profile shall conform to this profile to ensure basic interoperability and co-existence.

Bluetooth devices that conform to another Bluetooth profile may use adaptations of the generic procedures as specified by that other profile. They shall, however, be compatible with devices compliant to this profile at least on the level of the supported generic procedures.

If conformance to this profile is claimed, all capabilities indicated mandatory for this profile shall be supported in the specified manner (process-mandatory). This also applies for all optional and conditional capabilities for which support is indicated. All mandatory capabilities, and optional and conditional capabilities for which support is indicated, are subject to verification as part of the Bluetooth certification program.

3 USER INTERFACE ASPECTS

3.1 THE USER INTERFACE LEVEL

In the context of this specification, the user interface level refers to places (such as displays, dialog boxes, manuals, packaging, advertising, etc.) where users of Bluetooth devices encounters names, values and numerical representation of Bluetooth terminology and parameters.

This profile specifies the generic terms that should be used on the user interface level. These terms should be translated into languages supported by the Bluetooth device according to tables provided by the Bluetooth SIG.

3.2 REPRESENTATION OF BLUETOOTH PARAMETERS

3.2.1 Bluetooth device address (BD_ADDR)

3.2.1.1 Definition

BD_ADDR is the unique address of a Bluetooth device as defined in [1]. It is received from a remote device during the device discovery procedure.

3.2.1.2 Term on user interface level

When the Bluetooth address is referred to on UI level, the term 'Bluetooth Device Address' should be used.

3.2.1.3 Representation

On BB level the BD_ADDR is represented as 48 bits [1].

On the UI level the Bluetooth address shall be represented as 12 hexadecimal characters, possibly divided into sub-parts separated by':'.
(E.g., '000C3E3A4B69' or '00:0C:3E:3A:4B:69'.) At UI level, any number shall have the MSB -> LSB (from left to right) 'natural' ordering (e.g., the number '16' shall be shown as '0x10').

3.2.2 Bluetooth device name (the user-friendly name)

3.2.2.1 Definition

The Bluetooth device name is the user-friendly name that a Bluetooth device presents itself with. It is a character string returned in LMP_name_res as response to a LMP_name_req.

3.2.2.2 Term on user interface level

When the Bluetooth device name is referred to on UI level, the term 'Bluetooth Device Name' should be used.

3.2.2.3 Representation

The Bluetooth device name can be up to 248 bytes maximum according to [2]. It shall be coded according to Unicode UTF-8 (i.e. name entered on UI level may be down to 82 characters if UCS-2 is used).

A device can not expect that a general remote device is able to handle more than the first 40 characters of the Bluetooth device name. If a remote device has limited display capabilities, it may use only the first 20 characters.

3.2.3 Bluetooth passkey (Bluetooth PIN)

3.2.3.1 Definition

The Bluetooth PIN is used to authenticate two Bluetooth devices (that have not previously exchanged link keys) to each other and create a trusted relationship between them. The PIN is used in the pairing procedure (see Section 10.2) to generate the initial link key that is used for further authentication.

The PIN may be entered on UI level but may also be stored in the device; e.g. in the case of a device without sufficient MMI for entering and displaying digits.

3.2.3.2 Terms at user interface level

When the Bluetooth PIN is referred to on UI level, the term 'Bluetooth Passkey' should be used.

3.2.3.3 Representation

The Bluetooth PIN has different representations on different level. PIN_{BB} is used on baseband level, and PIN_{UI} is used on user interface level.

PIN_{BB} is the PIN used by [1] for calculating the initialization key during the pairing procedure. PIN_{UI} is the character representation of the PIN that is entered on UI level. The transformation between PIN_{BB} and PIN_{UI} shall be according to Unicode UTF-8.

According to [1], PIN_{BB} can be 128 bits (16 bytes). When PIN is entered on UI level (PIN_{UI}), it is to be coded into PIN_{BB} according to Unicode UTF-8 (i.e. if a

device supports entry of characters outside the Unicode range 0x00 - 0x7F, the maximum number of characters in the PIN_{UI} may be less than 16).

Examples:

User-entered code	Corresponding PIN_{BB}[0..length-1] (value as a sequence of octets in hexadecimal notation)
'0123'	length = 4, value = 0x30 0x31 0x32 0x33
'Ärlich'	length = 7, value = 0xC3 0x84 0x72 0x6C 0x69 0x63 0x68

All Bluetooth devices that support the bonding procedure and support PIN handling on UI level shall support UI level handling of PINs consisting of decimal digits. In addition, devices may support UI level handling of PINs consisting of general characters.

If a device has a fixed PIN (i.e. PIN is stored in the device and cannot be entered on UI level during pairing), the PIN shall be defined using decimal digits. A device that is expected to pair with a remote device that has restricted UI capabilities should ensure that the PIN can be entered on UI level as decimal digits.

3.2.4 Class of Device

3.2.4.1 Definition

Class of device is a parameter received during the device discovery procedure, indicating the type of device and which types of service that are supported.

3.2.4.2 Term on user interface level

The information within the Class of Device parameter should be referred to as 'Bluetooth Device Class' (i.e. the major and minor device class fields) and 'Bluetooth Service Type' (i.e. the service class field). The terms for the defined Bluetooth Device Types and Bluetooth Service Types are defined in [11].

When using a mix of information found in the Bluetooth Device Class and the Bluetooth Service Type, the term 'Bluetooth Device Type' should be used.

3.2.4.3 Representation

The Class of device is a bit field and is defined in [11]. The UI-level representation of the information in the Class of device is implementation specific.

3.3 PAIRING

Two procedures are defined that make use of the pairing procedure defined on LMP level (LMP-pairing, see Section 10.2). Either the user initiates the bonding procedure and enters the passkey with the explicit purpose of creating a bond (and maybe also a secure relationship) between two Bluetooth devices, or the user is requested to enter the passkey during the establishment procedure since the devices did not share a common link key beforehand. In the first case, the user is said to perform 'bonding (with entering of passkey)' and in the second case the user is said to 'authenticate using the passkey'.

4 MODES

	Procedure	Ref.	Support
1	Discoverability modes	4.1	
	Non-discoverable mode		C1
	Limited discoverable mode		C2
	General discoverable mode		C2
2	Connectability modes	4.1.3.3	
	Non-connectable mode		O
	Connectable mode		M
3	Pairing modes	4.2.2.2	
	Non-pairable mode		O
	Pairable mode		C3
C1: If limited discoverable mode is supported, non-discoverable mode is mandatory, otherwise optional.			
C2: A Bluetooth device shall support at least one discoverable mode (limited or/and general).			
C3: If the bonding procedure is supported, support for pairable mode is mandatory, otherwise optional.			

Table 4.1: Conformance requirements related to modes defined in this section

4.1 DISCOVERABILITY MODES

With respect to inquiry, a Bluetooth device shall be either in non-discoverable mode or in a discoverable mode. (The device shall be in one, and only one, discoverability mode at a time.) The two discoverable modes defined here are called limited discoverable mode and general discoverable mode. Inquiry is defined in [1].

When a Bluetooth device is in non-discoverable mode it does not respond to inquiry.

A Bluetooth device is said to be made discoverable, or set into a discoverable mode, when it is in limited discoverable mode or in general discoverable mode. Even when a Bluetooth device is made discoverable it may be unable to respond to inquiry due to other baseband activity [1]. A Bluetooth device that does not respond to inquiry for any of these two reasons is called a silent device.

After being made discoverable, the Bluetooth device shall be discoverable for at least $T_{GAP}(103)$.

4.1.1 Non-discoverable mode

4.1.1.1 Definition

When a Bluetooth device is in non-discoverable mode, it shall never enter the INQUIRY_RESPONSE state.

4.1.1.2 Term on UI-level

Bluetooth device is 'non-discoverable' or in 'non-discoverable mode'.

4.1.2 Limited discoverable mode

4.1.2.1 Definition

The limited discoverable mode should be used by devices that need to be discoverable only for a limited period of time, during temporary conditions or for a specific event. The purpose is to respond to a device that makes a limited inquiry (inquiry using the LIAC).

A Bluetooth device should not be in limited discoverable mode for more than $T_{GAP}(104)$. The scanning for the limited inquiry access code can be done either in parallel or in sequence with the scanning of the general inquiry access code. When in limited discoverable mode, one of the following options shall be used.

4.1.2.1.1 Parallel scanning

When a Bluetooth device is in limited discoverable mode, it shall enter the INQUIRY_SCAN state at least once in $T_{GAP}(102)$ and scan for the GIAC and the LIAC for at least $T_{GAP}(101)$.

4.1.2.1.2 Sequential scanning

When a Bluetooth device is in limited discoverable mode, it shall enter the INQUIRY_SCAN state at least once in $T_{GAP}(102)$ and scan for the GIAC for at least $T_{GAP}(101)$ and enter the INQUIRY_SCAN state more often than once in $T_{GAP}(102)$ and scan for the LIAC for at least $T_{GAP}(101)$.

If an inquiry message is received when in limited discoverable mode, the entry into the INQUIRY_RESPONSE state takes precedence over the next entries into INQUIRY_SCAN state until the inquiry response is completed.

4.1.2.2 Conditions

When a device is in limited discoverable mode it shall set bit no 13 in the Major Service Class part of the Class of Device/Service field [11].

4.1.2.3 Term on UI-level

Bluetooth device is 'discoverable' or in 'discoverable mode'.

4.1.3 General discoverable mode

4.1.3.1 Definition

The general discoverable mode shall be used by devices that need to be discoverable continuously or for no specific condition. The purpose is to respond to a device that makes a general inquiry (inquiry using the GIAC).

4.1.3.2 Conditions

When a Bluetooth device is in general discoverable mode, it shall enter the INQUIRY_SCAN state more often than once in $T_{GAP}(102)$ and scan for the GIAC for at least $T_{GAP}(101)$.

A device in general discoverable mode shall not respond to a LIAC inquiry.

4.1.3.3 Term on UI-level

Bluetooth device is 'discoverable' or in 'discoverable mode'.

4.2 CONNECTABILITY MODES

With respect to paging, a Bluetooth device shall be either in non-connectable mode or in connectable mode. Paging is defined in [1].

When a Bluetooth device is in non-connectable mode it does not respond to paging. When a Bluetooth device is in connectable mode it responds to paging.

4.2.1 Non-connectable mode

4.2.1.1 Definition

When a Bluetooth device is in non-connectable mode it shall never enter the PAGE_SCAN state.

4.2.1.2 Term on UI-level

Bluetooth device is 'non-connectable' or in 'non-connectable mode'.

4.2.2 Connectable mode

4.2.2.1 Definition

When a Bluetooth device is in connectable mode it shall periodically enter the PAGE_SCAN state.

4.2.2.2 Term on UI-level

Bluetooth device is 'connectable' or in 'connectable mode'.

4.3 PAIRING MODES

With respect to pairing, a Bluetooth device shall be either in non-pairable mode or in pairable mode. In pairable mode the Bluetooth device accepts paring – i.e. creation of bonds – initiated by the remote device, and in non-pairable mode it does not. Pairing is defined in [1] and [2].

4.3.1 Non-pairable mode

4.3.1.1 Definition

When a Bluetooth device is in non-pairable mode it shall respond to a received LMP_in_rand with LMP_not_accepted with the reason *pairing not allowed*.

4.3.1.2 Term on UI-level

Bluetooth device is 'non-bondable' or in 'non-bondable mode' or "does not accept bonding".

4.3.2 Pairable mode

4.3.2.1 Definition

When a Bluetooth device is in pairable mode it shall respond to a received LMP_in_rand with LMP_accepted (or with LMP_in_rand if it has a fixed PIN).

4.3.2.2 Term on UI-level

Bluetooth device is 'bondable' or in 'bondable mode' or "accepts bonding".

5 SECURITY ASPECTS

	Procedure	Ref.	Support
1	Authentication	5.1	C1
2	Security modes	5.2	
	Security mode 1		O
	Security mode 2		C2
	Security mode 3		C2
C1: If security mode 1 is the only security mode that is supported, support for authentication is optional, otherwise mandatory. (Note: support for LMP-authentication and LMP-pairing is mandatory according [2] independent of which security mode that is used.)			
C2: If security mode 1 is not the only security mode that is supported, then support for at least one of security mode 2 or security mode 3 is mandatory.			

Table 5.1: Conformance requirements related to the generic authentication procedure and the security modes defined in this section

5.1 AUTHENTICATION

5.1.1 Purpose

The generic authentication procedure describes how the LMP-authentication and LMP-pairing procedures are used when authentication is initiated by one Bluetooth device towards another, depending on if a link key exists or not and if pairing is allowed or not.

5.1.2 Term on UI level

'Bluetooth authentication'.

5.1.3 Procedure

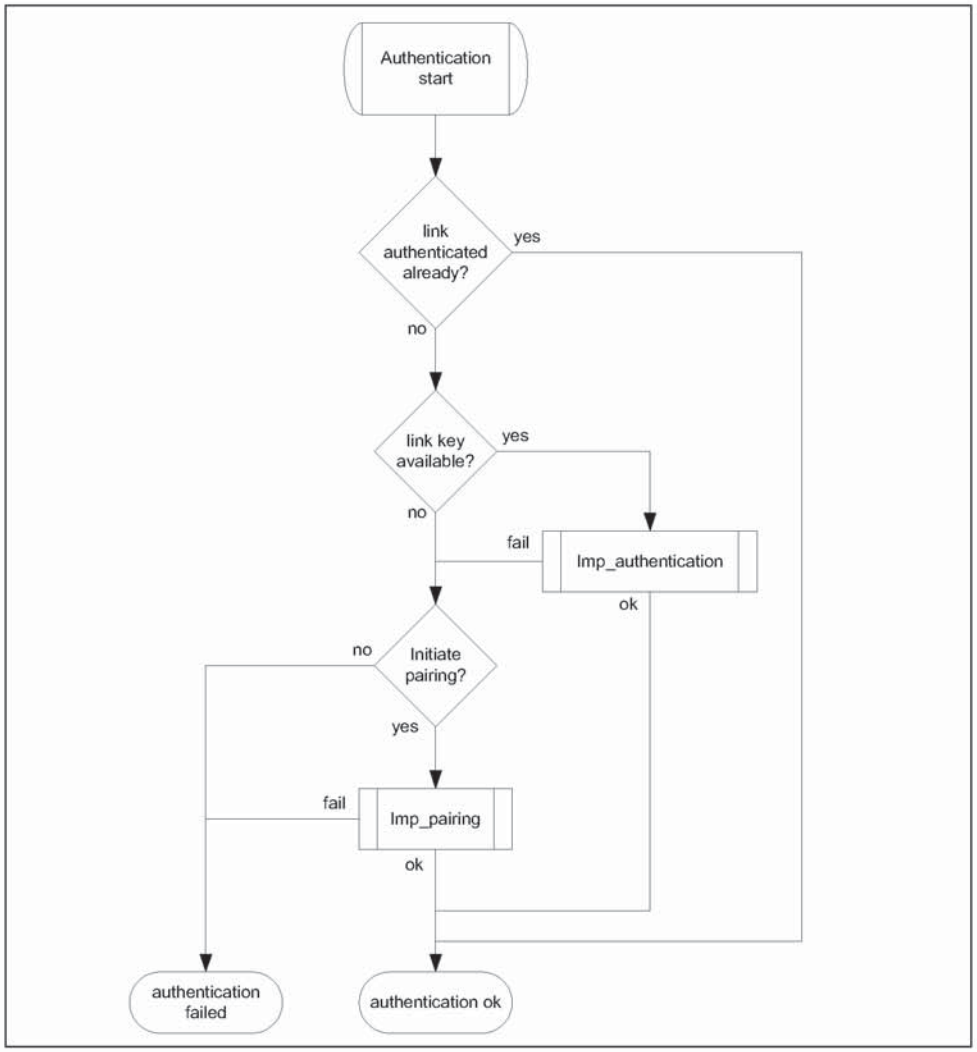


Figure 5.1: Definition of the generic authentication procedure.

5.1.4 Conditions

The device that initiates authentication has to be in security mode 2 or in security mode 3.

5.2 SECURITY MODES

The following flow chart describes where in the channel establishment procedures initiation of authentication takes place, depending on which security mode the Bluetooth device is in.

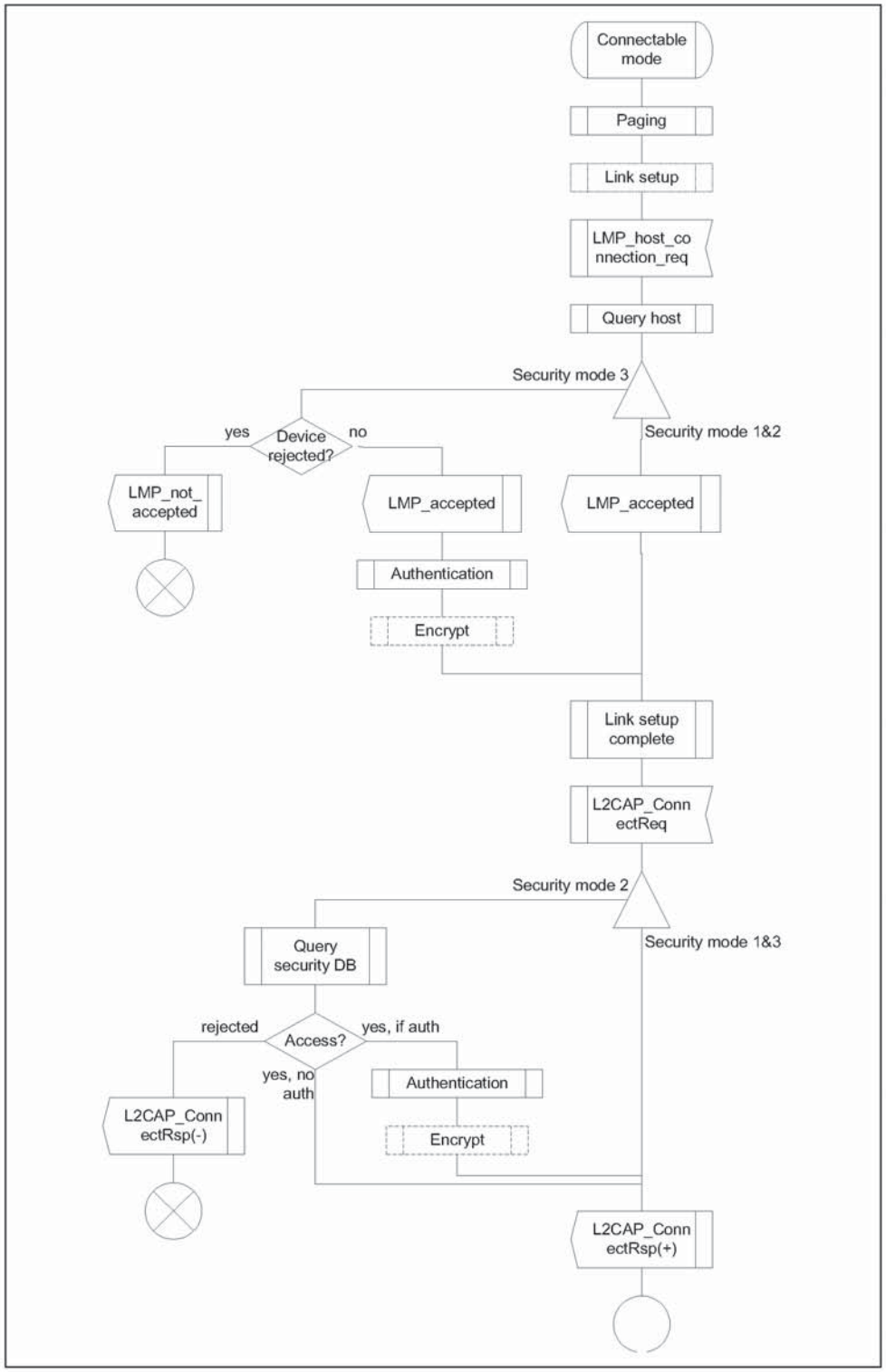


Figure 5.2: Illustration of channel establishment using different security modes.

When authentication is initiated towards a Bluetooth device, it shall act according to [2] and the current pairing mode, independent of which security mode it is in.

5.2.1 Security mode 1 (non-secure)

When a Bluetooth device is in security mode 1 it shall never initiate any security procedure (i.e., it shall never send LMP_au_rand, LMP_in_rand or LMP_encryption_mode_req).

5.2.2 Security mode 2 (service level enforced security)

When a Bluetooth device is in security mode 2 it shall not initiate any security procedure before a channel establishment request (L2CAP_ConnectReq) has been received or a channel establishment procedure has been initiated by itself. (The behavior of a device in security mode 2 is further described in [10].) Whether a security procedure is initiated or not depends on the security requirements of the requested channel or service.

A Bluetooth device in security mode 2 should classify the security requirements of its services using at least the following attributes:

- Authorization required;
- Authentication required;
- Encryption required.

Note: Security mode 1 can be considered (at least from a remote device point of view) as a special case of security mode 2 where no service has registered any security requirements.

5.2.3 Security modes 3 (link level enforced security)

When a Bluetooth device is in security mode 3 it shall initiate security procedures before it sends LMP_link_setup_complete. (The behavior of a device in security mode 3 is as described in [2].)

A Bluetooth device in security mode 3 may reject the host connection request (respond with LMP_not_accepted to the LMP_host_connection_req) based on settings in the host (e.g. only communication with pre-paired devices allowed).

6 IDLE MODE PROCEDURES

The inquiry and discovery procedures described here are applicable only to the device that initiates them (A). The requirements on the behavior of B is according to the modes specified in Section 4 and to [2].

	Procedure	Ref.	Support
1	General inquiry	6.1	C1
2	Limited inquiry	6.2	C1
3	Name discovery	6.3	O
4	Device discovery	6.4	O
5	Bonding	6.5	O
C1: If initiation of bonding is supported, support for at least one inquiry procedure is mandatory, otherwise optional. (Note: support for LMP-pairing is mandatory [2].)			

6.1 GENERAL INQUIRY

6.1.1 Purpose

The purpose of the general inquiry procedure is to provide the initiator with the Bluetooth device address, clock, Class of Device and used page scan mode of general discoverable devices (i.e. devices that are in range with regard to the initiator and are set to scan for inquiry messages with the General Inquiry Access Code). Also devices in limited discoverable mode will be discovered using general inquiry.

The general inquiry should be used by devices that need to discover devices that are made discoverable continuously or for no specific condition.

6.1.2 Term on UI level

'Bluetooth Device Inquiry'.

6.1.3 Description

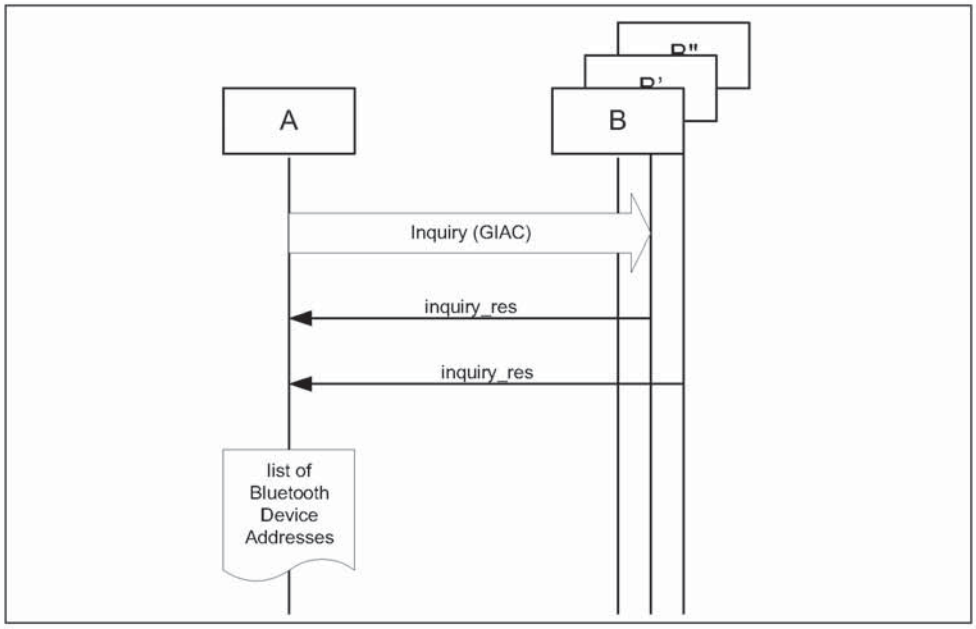


Figure 6.1: General inquiry ,where B is a device in non-discoverable mode, B´ is a device in limited discoverable mode and B" is a device in general discoverable mode. (Note that all discoverable devices are discovered using general inquiry, independent of which discoverable mode they are in.)

6.1.4 Conditions

When general inquiry is initiated by a Bluetooth device, it shall be in the INQUIRY state for at least $T_{GAP}(100)$ and perform inquiry using the GIAC.

In order to receive inquiry response, the remote devices in range have to be made discoverable (limited or general).

6.2 LIMITED INQUIRY

6.2.1 Purpose

The purpose of the limited inquiry procedure is to provide the initiator with the Bluetooth device address, clock, Class of Device and used page scan mode of limited discoverable devices. The latter devices are devices that are in range with regard to the initiator, and may be set to scan for inquiry messages with the Limited Inquiry Access Code, in addition to scanning for inquiry messages with the General Inquiry Access Code.

The limited inquiry should be used by devices that need to discover devices that are made discoverable only for a limited period of time, during temporary conditions or for a specific event. Since it is not guaranteed that the