It Just (Net)works

The Truth About iOS'
Multipeer Connectivity Framework

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Malaysia

About me

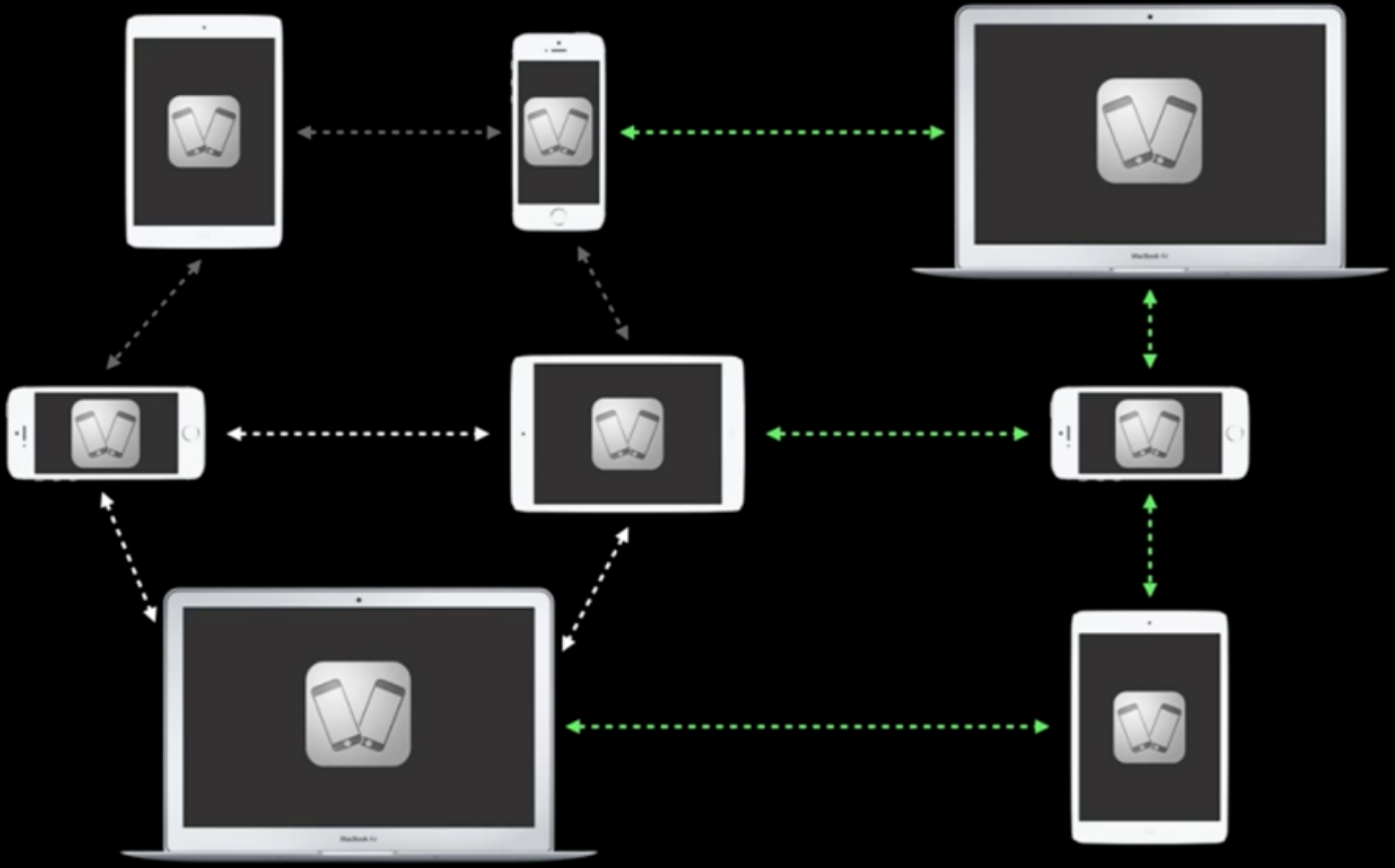
- iOS Security Researcher at Data Theorem
- Before: Principal Security Consultant at iSEC Partners
    - Led iSEC Partners' audit of Cryptocat iOS
- Tools: SSLyze, Introspy, iOS SSL Kill Switch

Agenda

- What is Multipeer Connectivity?
- Quick intro to the MC API
- Reversing the MC protocol(s)
- Security analysis of MC

What is
Multipeer Connectivity?

Multipeer Connectivity

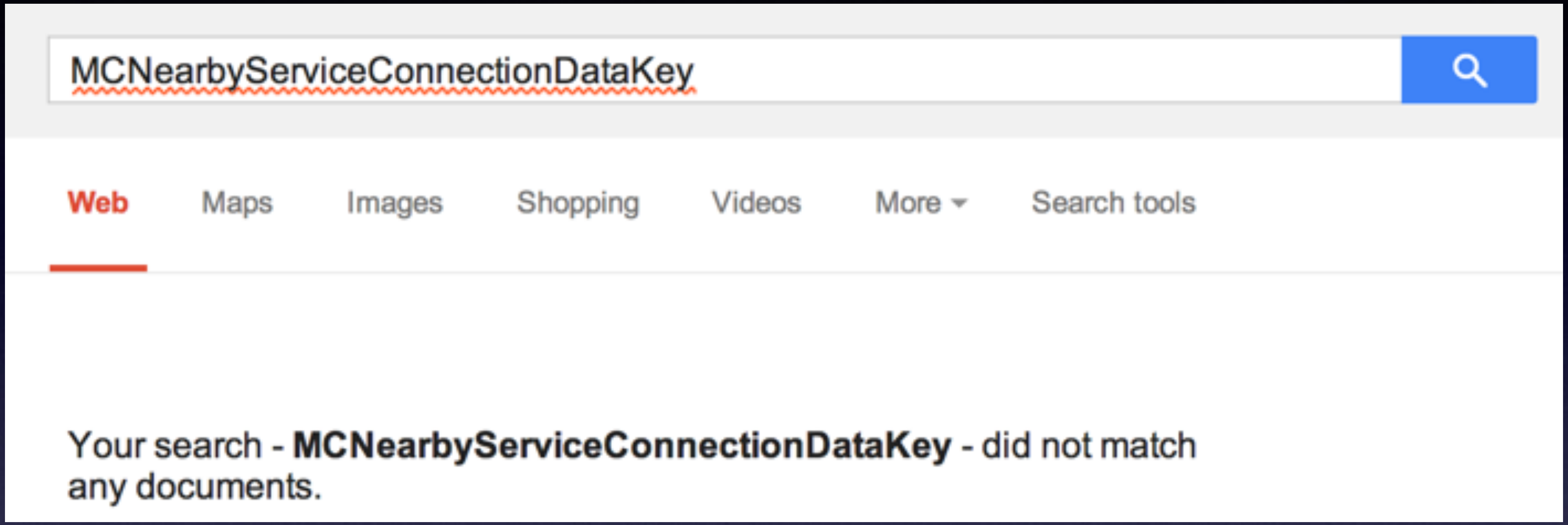


Multipeer Connectivity

- Audibly: Stream songs to other devices
- iTranslate Voice: “AirTranslate”
- FireChat: Anonymous “off-the-grid“ chat
- Tons of possible use cases: collaborative editing, file sharing, multiplayer gaming, etc.

Demo

Motivation


MCNearbyServiceConnectionDataKey

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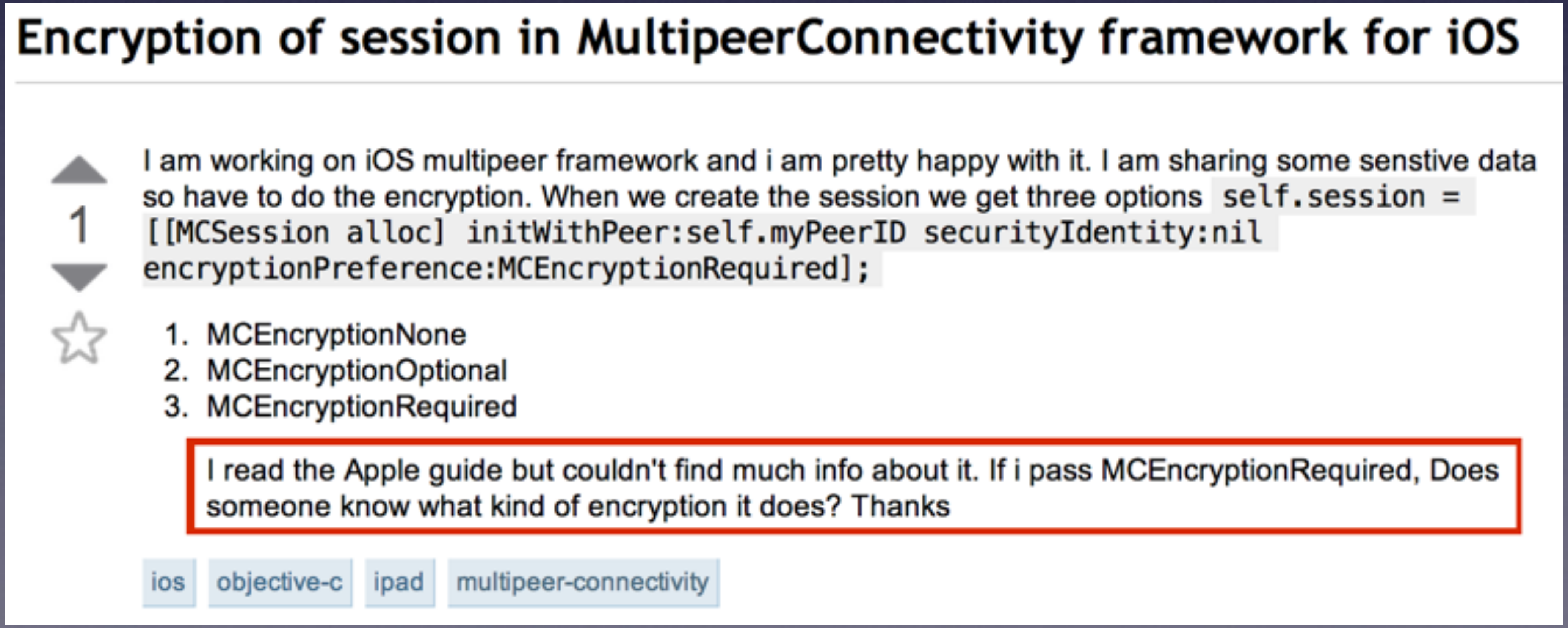
Your search - **MCNearbyServiceConnectionDataKey** - did not match any documents.


Encryption of session in MultipeerConnectivity framework for iOS

1

I am working on iOS multipeer framework and i am pretty happy with it. I am sharing some senstive data so have to do the encryption. When we create the session we get three options `self.session = [[MCSession alloc] initWithPeer:self.myPeerID securityIdentity:nil encryptionPreference:MCEncryptionRequired];`

1. MCEncryptionNone
2. MCEncryptionOptional
3. MCEncryptionRequired

I read the Apple guide but couldn't find much info about it. If i pass MCEncryptionRequired, Does someone know what kind of encryption it does? Thanks

ios objective-c ipad multipeer-connectivity

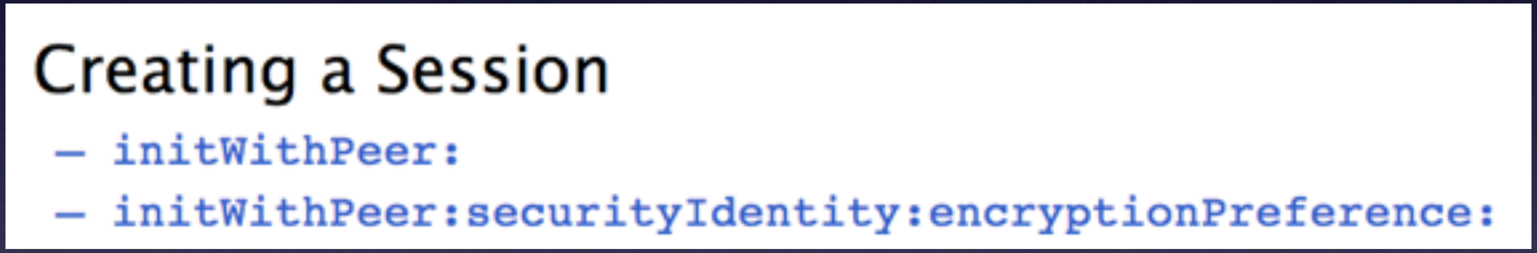
Quick intro to the MC API

MC API

- **1. Discovery phase: Establish a session**
  - Per-App service name ("og-firechat" for FireChat)
  - The App can browse for nearby peers advertising the MC service
    - And then send an invitation to discovered peers
  - The App can advertise its own local MC service to nearby peers
    - And then accept or reject invitations from other peers

MC API

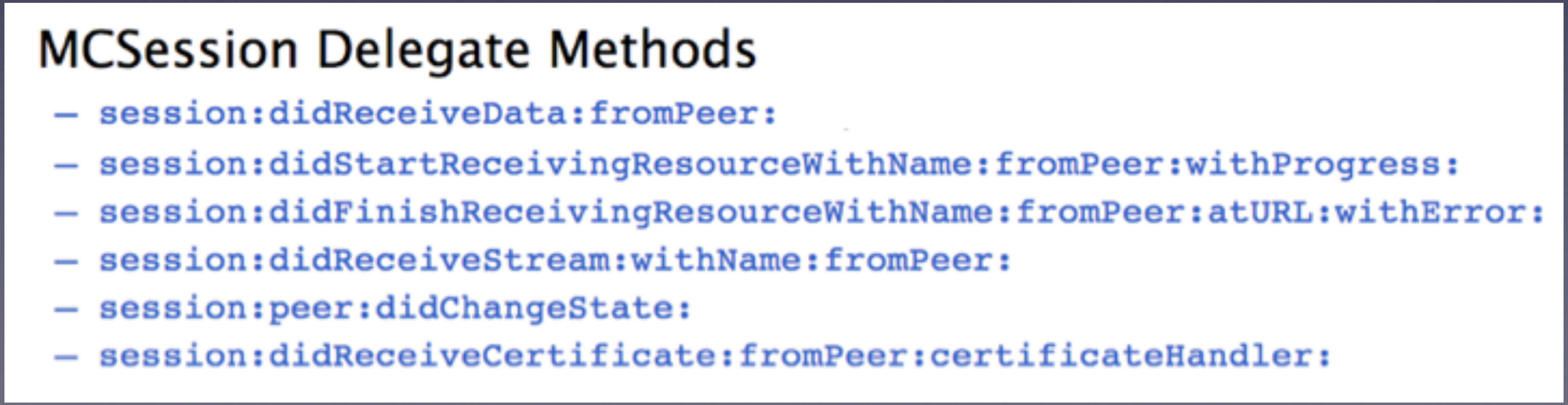
- **2. Session phase: Exchange data**
  - A session can be established after one or multiple peers accepted a pairing invitation:



Creating a Session

```
– initWithPeer:
– initWithPeer:securityIdentity:encryptionPreference:
```

  - The App can then exchange data with these peers:

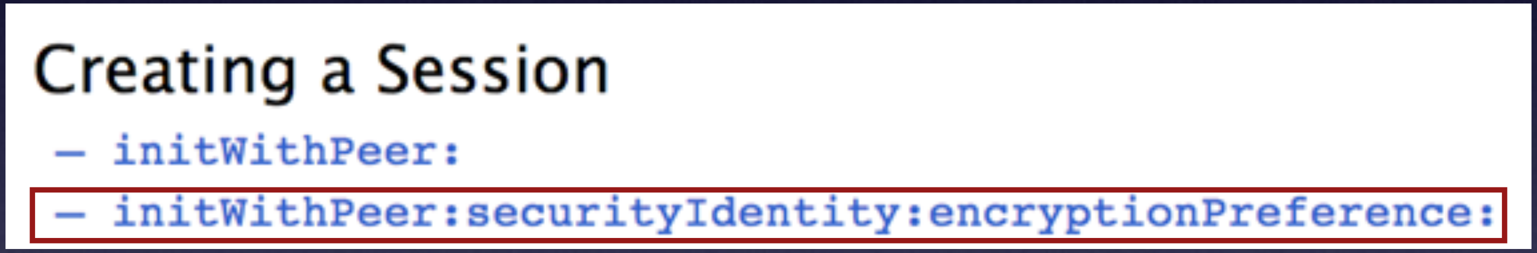


MCSession Delegate Methods

```
– session:didReceiveData:fromPeer:
– session:didStartReceivingResourceWithName:fromPeer:withProgress:
– session:didFinishReceivingResourceWithName:fromPeer:atURL:withError:
– session:didReceiveStream:withName:fromPeer:
– session:peer:didChangeState:
– session:didReceiveCertificate:fromPeer:certificateHandler:
```

MC API

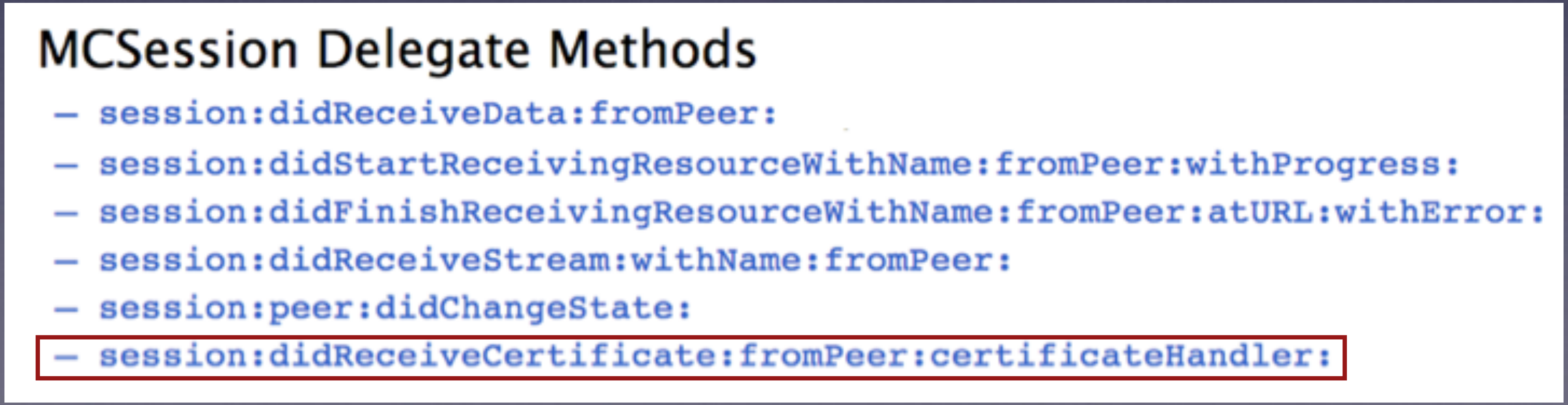
- **2. Session phase: Exchange data**
  - A session can be established after one or multiple peers accepted a pairing invitation:



Creating a Session

```
– initWithPeer:
– initWithPeer:securityIdentity:encryptionPreference:
```

  - The App can then exchange data with these peers:



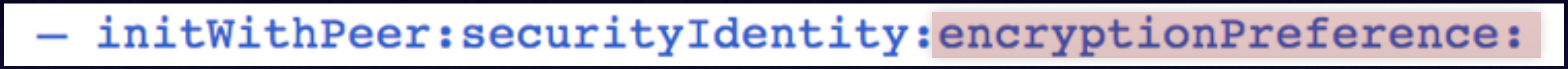
MCSession Delegate Methods

```
– session:didReceiveData:fromPeer:
– session:didStartReceivingResourceWithName:fromPeer:withProgress:
– session:didFinishReceivingResourceWithName:fromPeer:atURL:withError:
– session:didReceiveStream:withName:fromPeer:
– session:peer:didChangeState:
– session:didReceiveCertificate:fromPeer:certificateHandler:
```

Demo

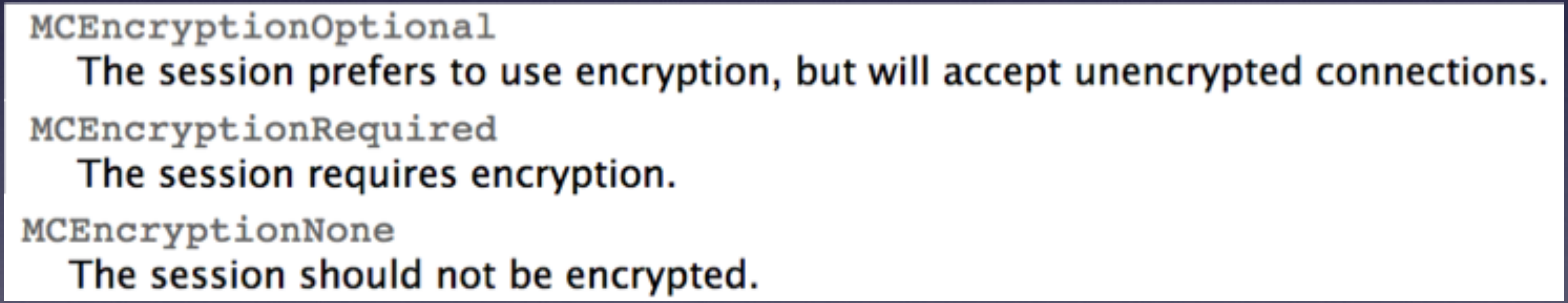
MC API - Encryption

- The App can specify an *encryptionPreference*



```
– initWithPeer:securityIdentity:encryptionPreference:
```

- Three encryption levels:

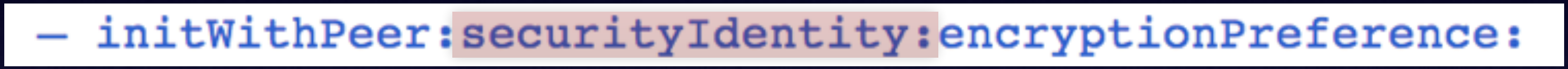


MCEncryptionOptional
The session prefers to use encryption, but will accept unencrypted connections.
MCEncryptionRequired
The session requires encryption.
MCEncryptionNone
The session should not be encrypted.

- No further explanation in the documentation

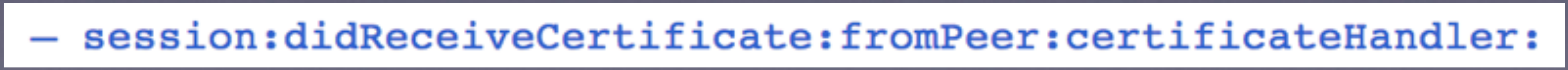
MC API - Authentication

- The App can specify a *securityIdentity*



```
– initWithPeer:securityIdentity:encryptionPreference:
```

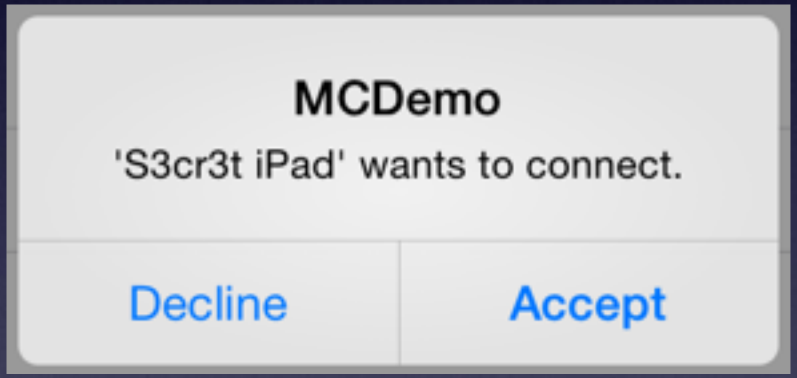
- A "security identity" is an X509 certificate and the corresponding private key
    - The peer's identify when pairing with other peers
- A callback has to be implemented for validating other peers' certificates/identities during pairing:



```
– session:didReceiveCertificate:fromPeer:certificateHandler:
```

MC API - Peer Management

- How MC sessions get established
- “Automated"/default peer management
  - Invite prompt before pairing:



MCDemo

'S3cr3t iPad' wants to connect.

- "Manual" peer management
  - Developers can customize how pairing is done
  - Fully transparent pairing (ie. no user prompts) can be implemented

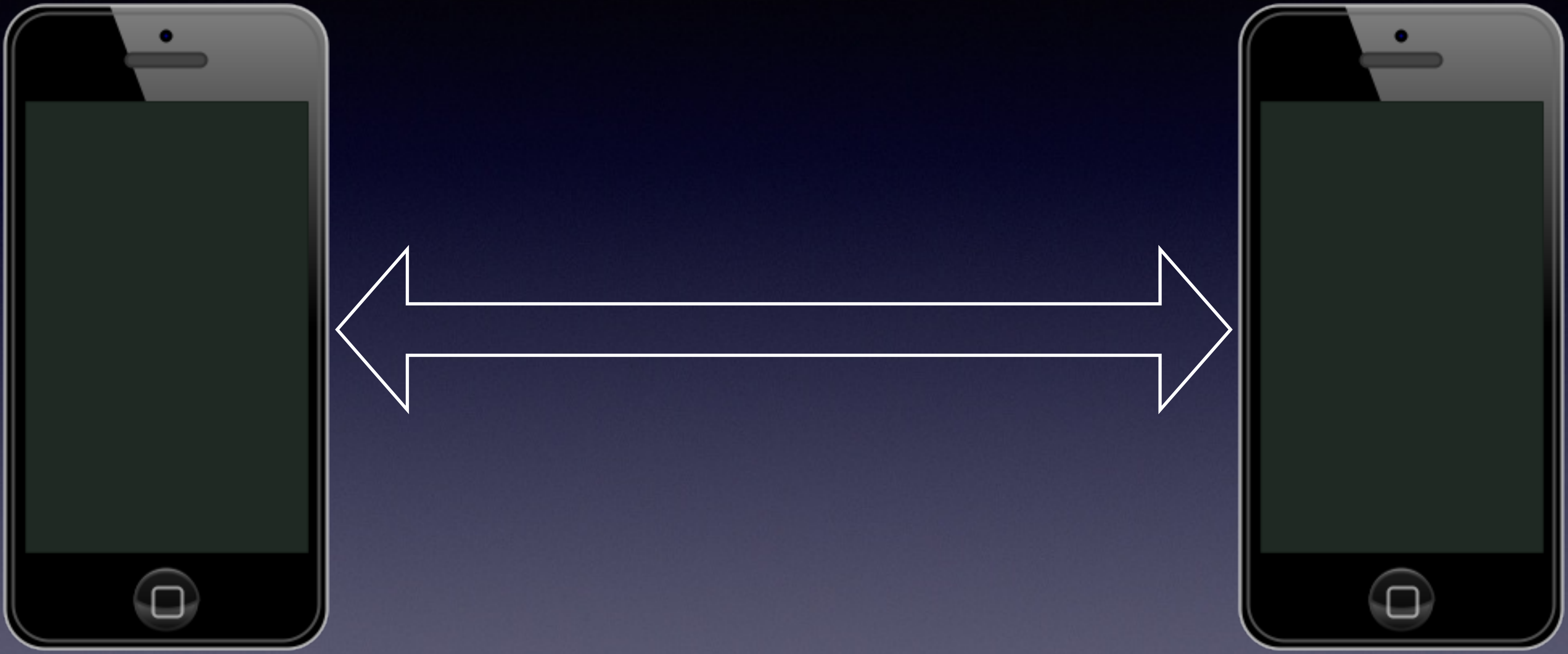
MC API - Security

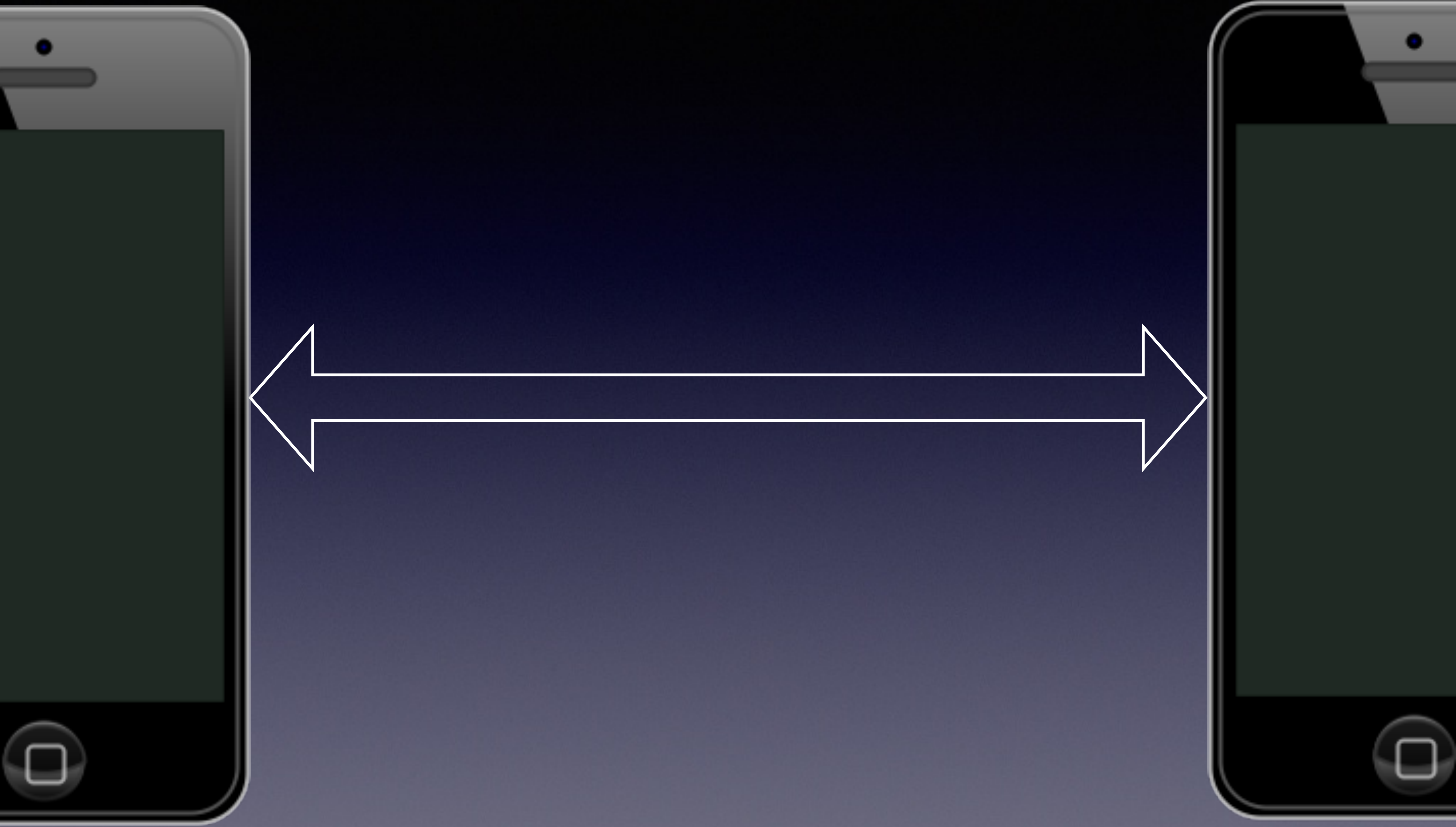
- **Peer Management**
  - Automated or Manual
- **Encryption**
  - None, Optional or Required
- **Authentication**
  - Enabled or Disabled

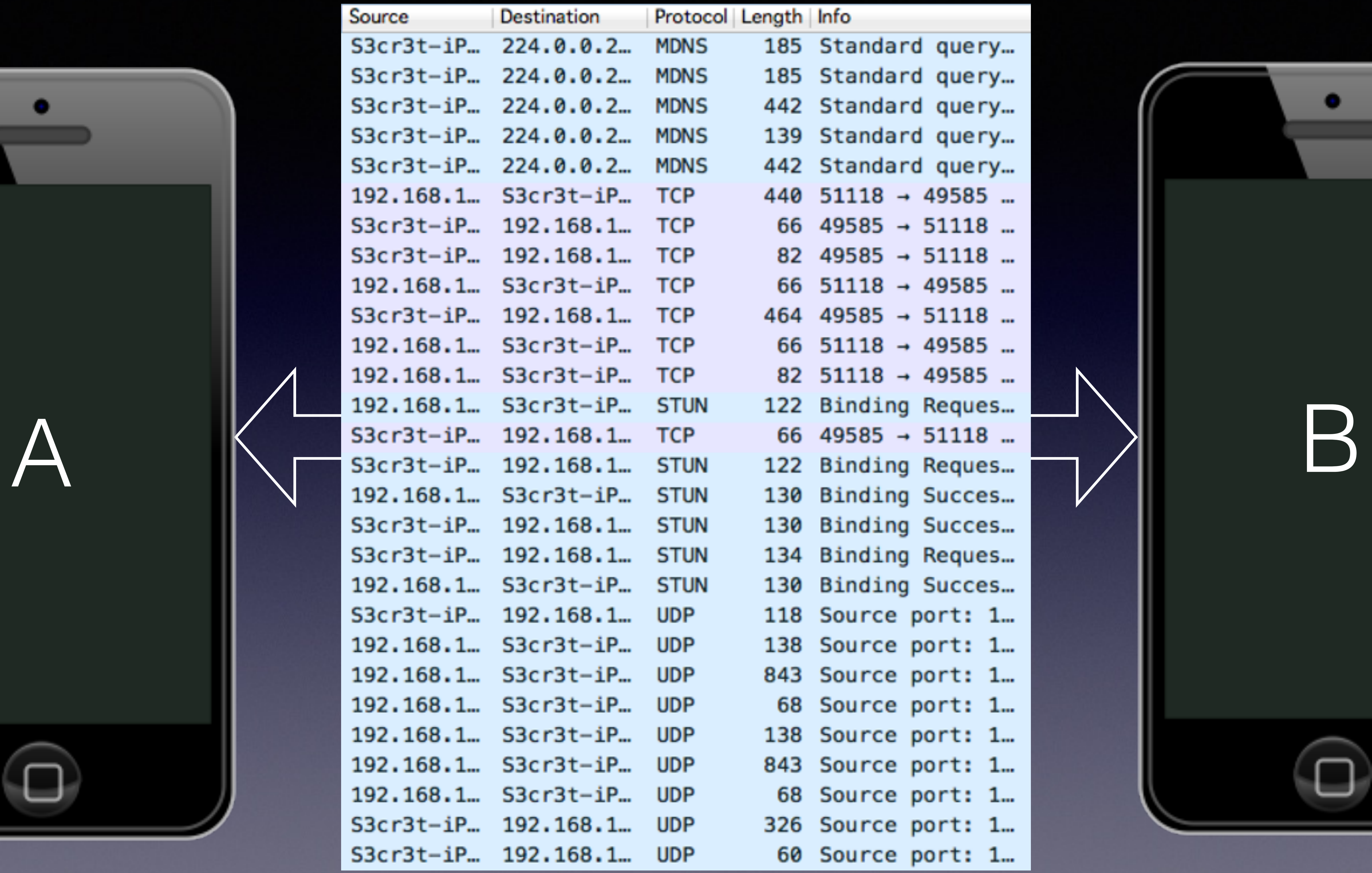
Reversing the MC protocol(s)

Test Setup

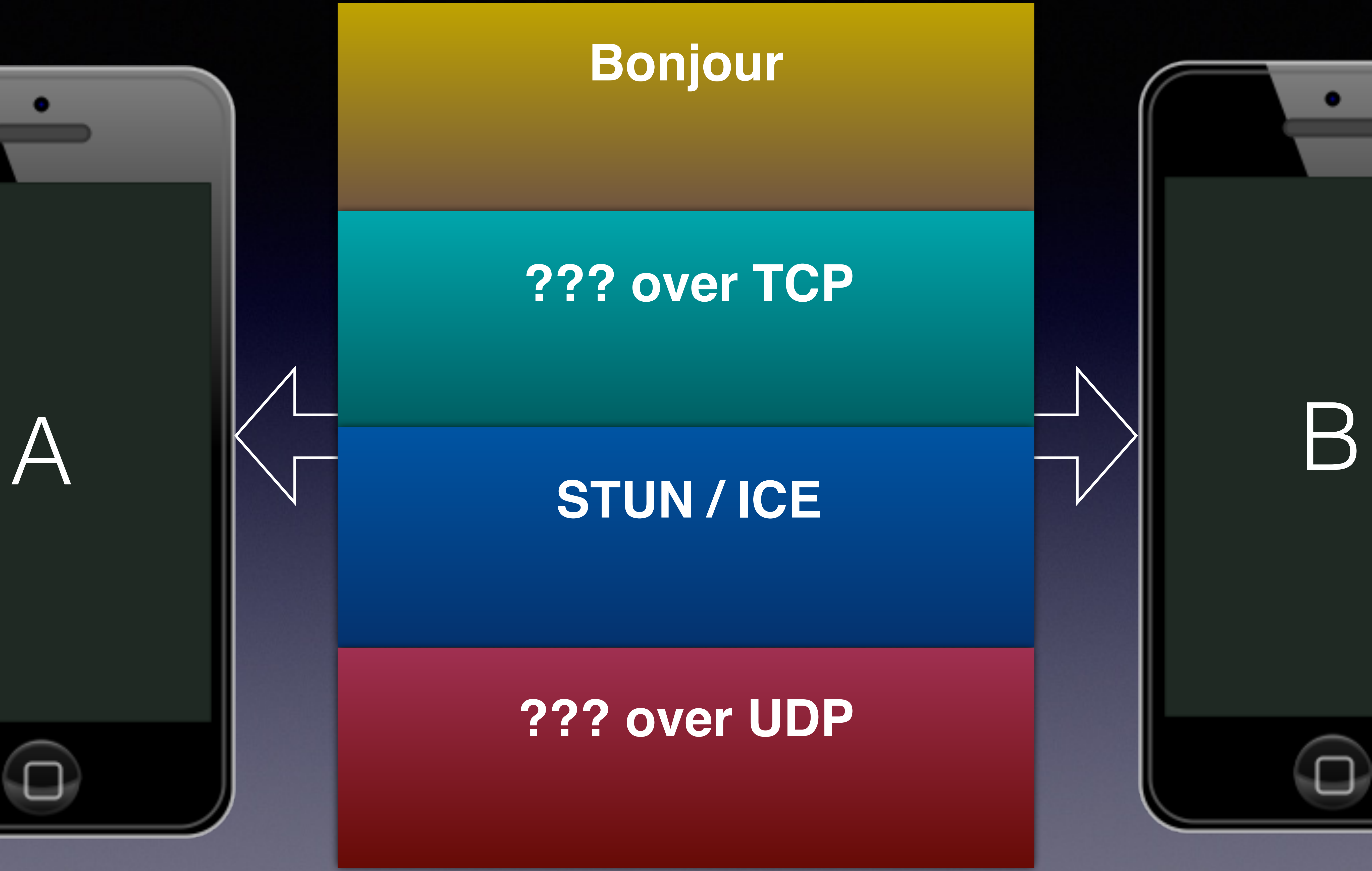
- Macbook in WiFi Access Point mode + Wireshark
- Sample MC App with default MC settings
- Two devices:
  - iPad Air with Bluetooth disabled
  - iOS Simulator



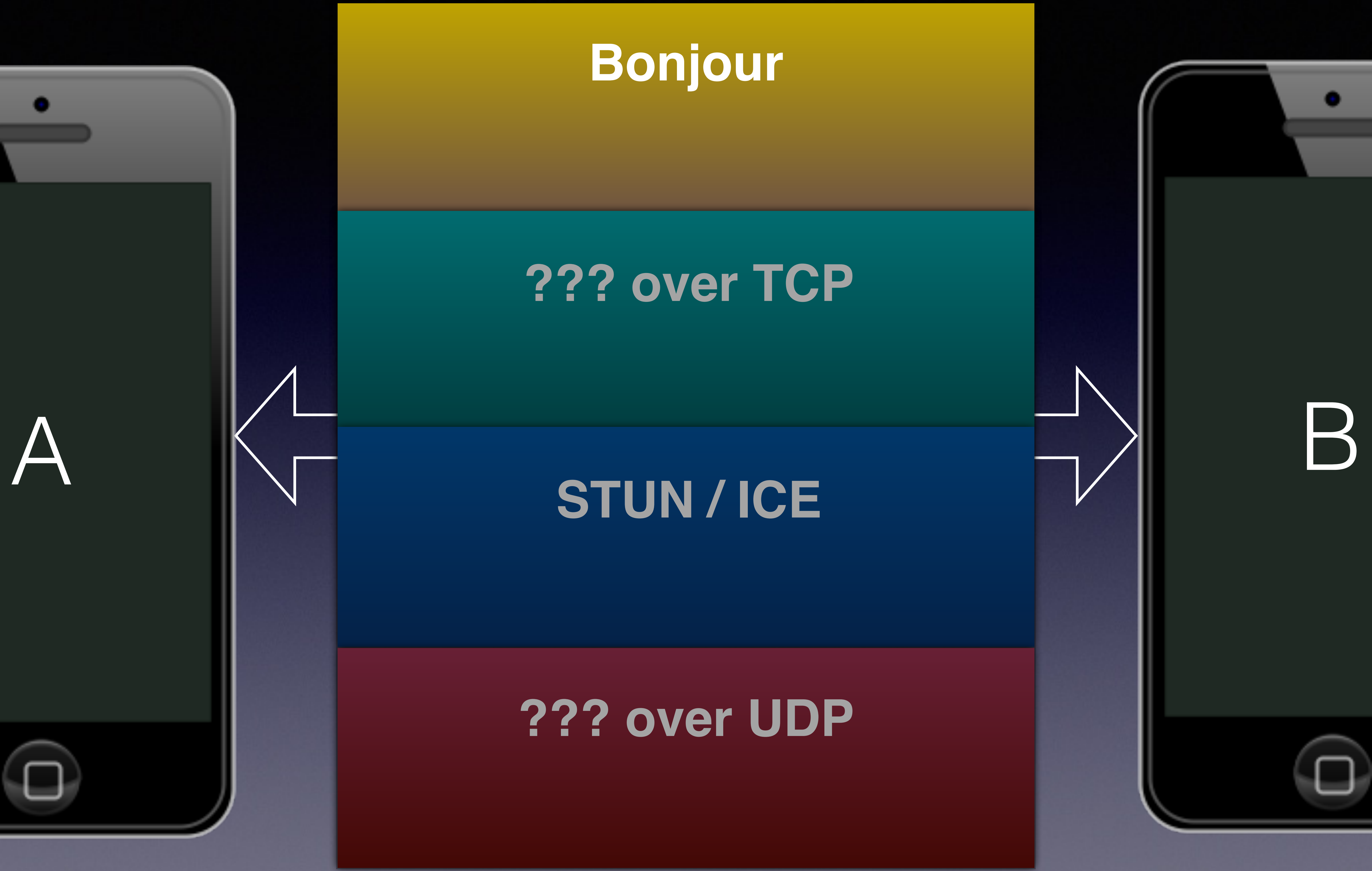




Source	Destination	Protocol	Length	Info
S3cr3t-iP…	224.0.0.2…	MDNS	185	Standard query…
S3cr3t-iP…	224.0.0.2…	MDNS	185	Standard query…
S3cr3t-iP…	224.0.0.2…	MDNS	442	Standard query…
S3cr3t-iP…	224.0.0.2…	MDNS	139	Standard query…
S3cr3t-iP…	224.0.0.2…	MDNS	442	Standard query…
192.168.1…	S3cr3t-iP…	TCP	440	51118 → 49585 …
S3cr3t-iP…	192.168.1…	TCP	66	49585 → 51118 …
S3cr3t-iP…	192.168.1…	TCP	82	49585 → 51118 …
192.168.1…	S3cr3t-iP…	TCP	66	51118 → 49585 …
S3cr3t-iP…	192.168.1…	TCP	464	49585 → 51118 …
192.168.1…	S3cr3t-iP…	TCP	66	51118 → 49585 …
192.168.1…	S3cr3t-iP…	TCP	82	51118 → 49585 …
192.168.1…	S3cr3t-iP…	STUN	122	Binding Reques…
S3cr3t-iP…	192.168.1…	TCP	66	49585 → 51118 …
S3cr3t-iP…	192.168.1…	STUN	122	Binding Reques…
192.168.1…	S3cr3t-iP…	STUN	130	Binding Succes…
S3cr3t-iP…	192.168.1…	STUN	130	Binding Succes…
S3cr3t-iP…	192.168.1…	STUN	134	Binding Reques…
192.168.1…	S3cr3t-iP…	STUN	130	Binding Succes…
S3cr3t-iP…	192.168.1…	UDP	118	Source port: 1…
192.168.1…	S3cr3t-iP…	UDP	138	Source port: 1…
192.168.1…	S3cr3t-iP…	UDP	843	Source port: 1…
192.168.1…	S3cr3t-iP…	UDP	68	Source port: 1…
192.168.1…	S3cr3t-iP…	UDP	138	Source port: 1…
192.168.1…	S3cr3t-iP…	UDP	843	Source port: 1…
192.168.1…	S3cr3t-iP…	UDP	68	Source port: 1…
S3cr3t-iP…	192.168.1…	UDP	326	Source port: 1…
S3cr3t-iP…	192.168.1…	UDP	60	Source port: 1…



A
Bonjour
??? over TCP
STUN / ICE
??? over UDP
B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Bonjour
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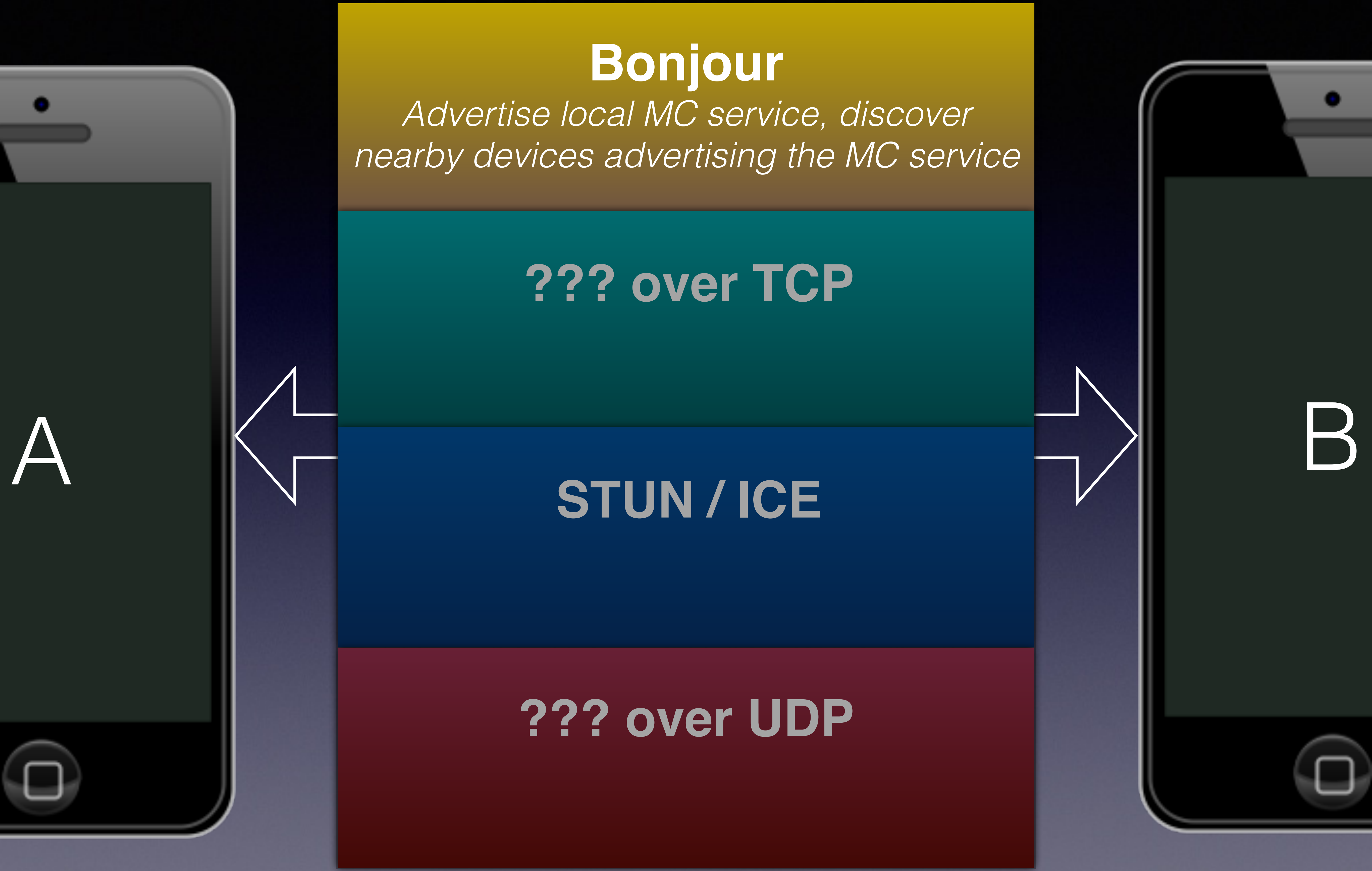
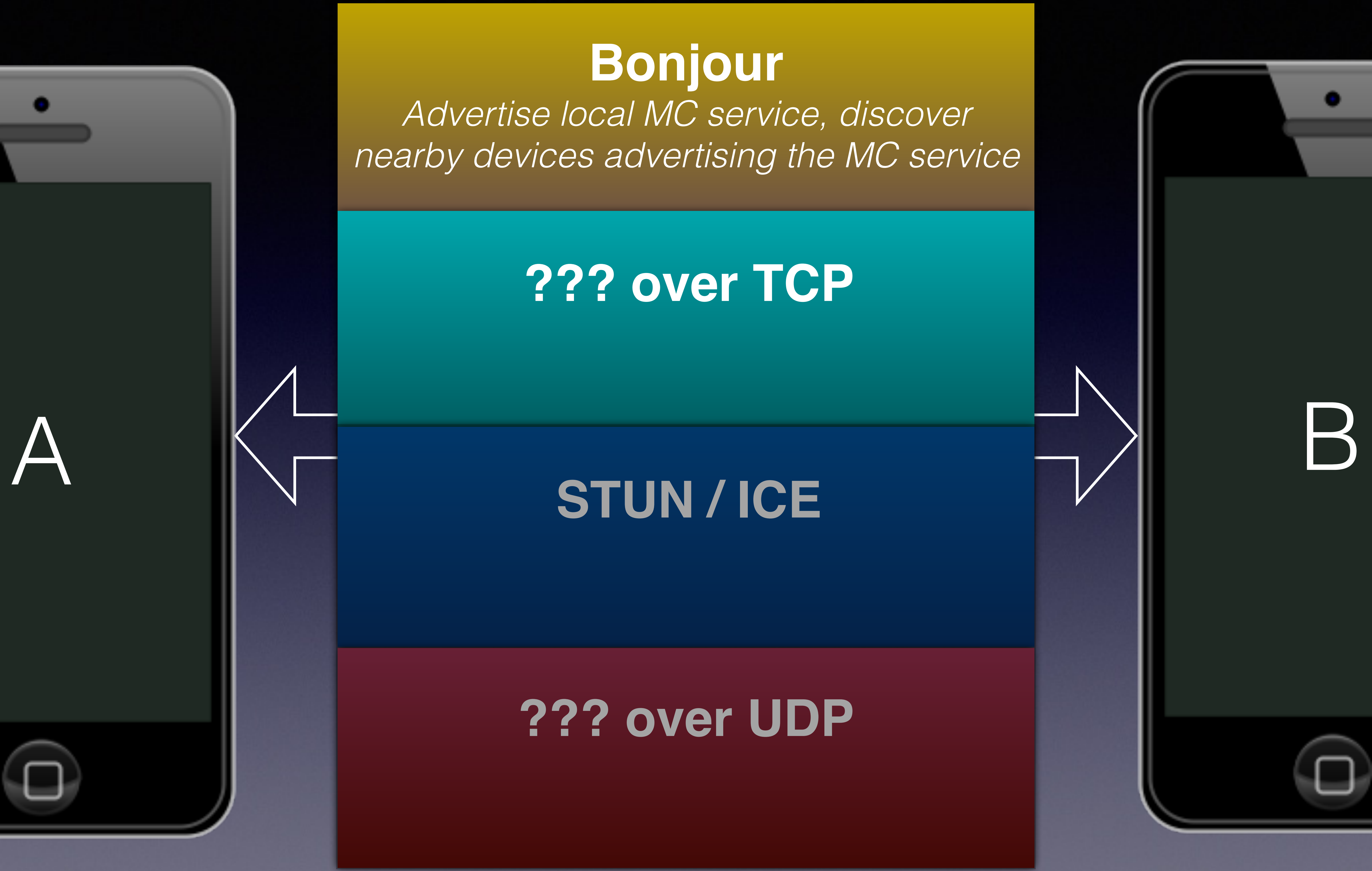

Bonjour
Advertise local MC service, discover nearby devices advertising the MC service
??? over TCP
STUN / ICE
??? over UDP
A
B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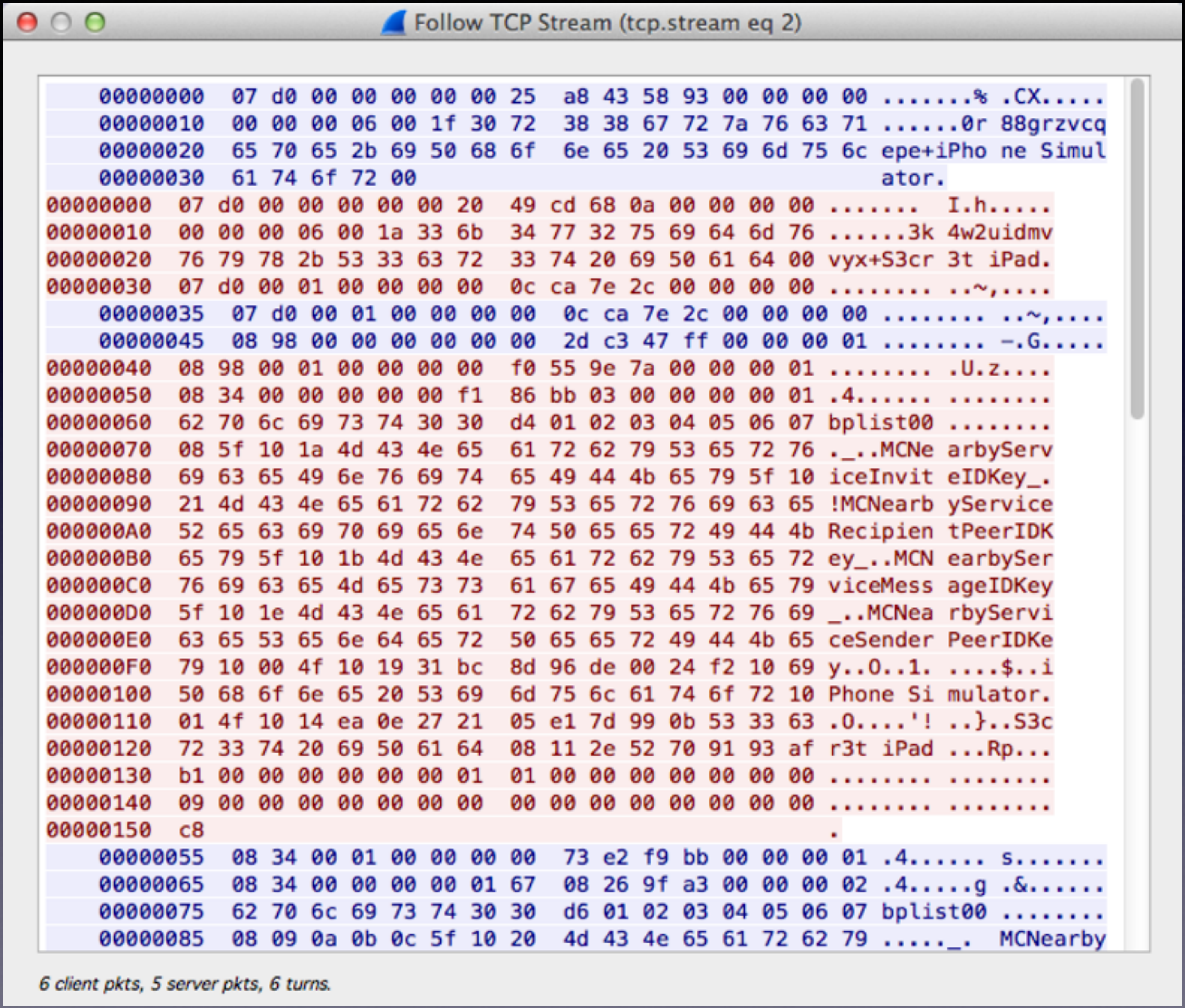
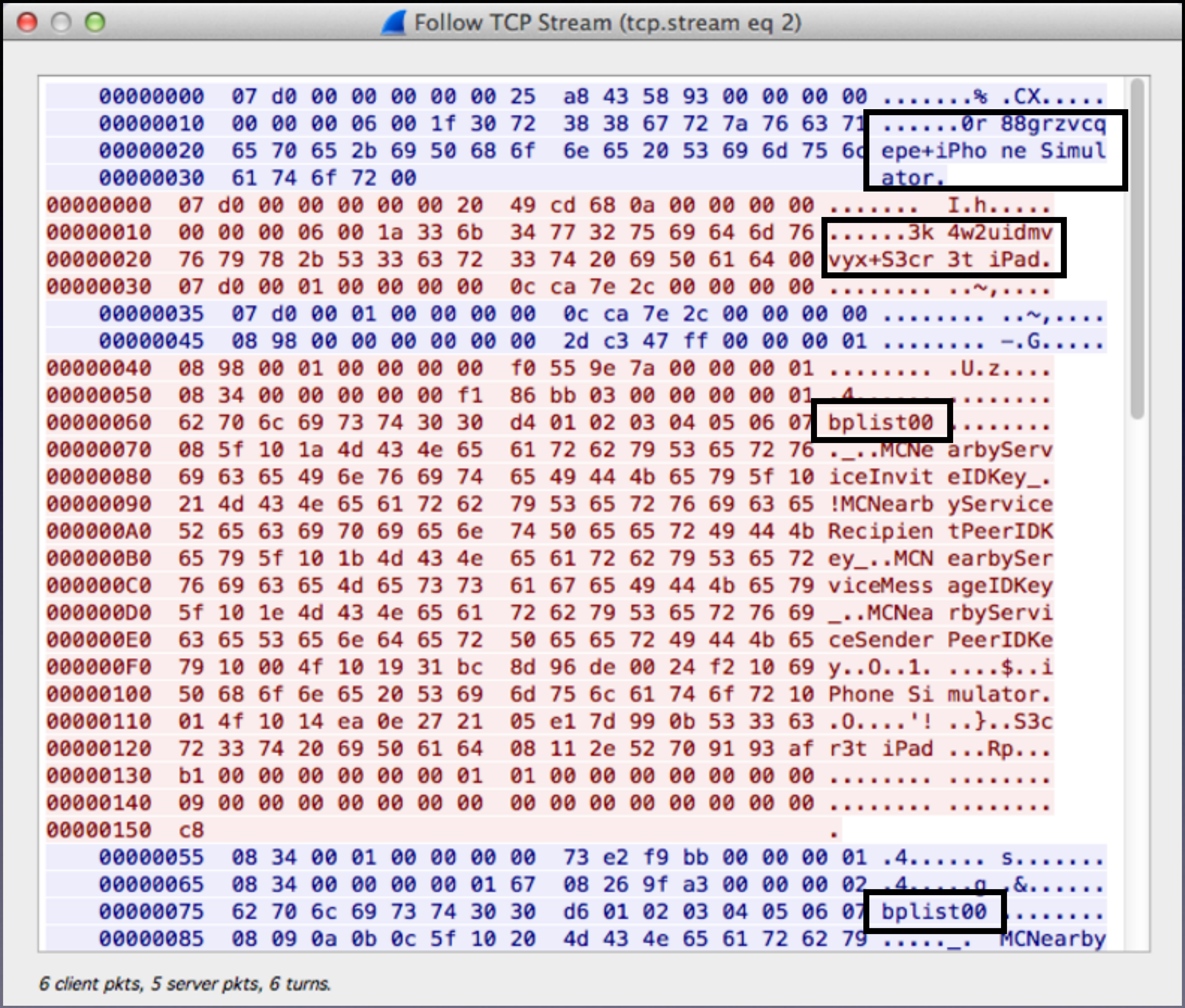
Bonjour
Advertise local MC service, discover nearby devices advertising the MC service
??? over TCP
STUN / ICE
??? over UDP
B



```
    00000000  07 d0 00 00 00 00 00 25  a8 43 58 93 00 00 00 00 .......% .CX.....
    00000010  00 00 00 06 00 1f 30 72  38 38 67 72 7a 76 63 71 ......0r 88grzvcq
    00000020  65 70 65 2b 69 50 68 6f  6e 65 20 53 69 6d 75 6c epe+iPho ne Simul
    00000030  61 74 6f 72 00                                    ator.
00000000  07 d0 00 00 00 00 00 20  49 cd 68 0a 00 00 00 00 .......  I.h.....
00000010  00 00 00 06 00 1a 33 6b  34 77 32 75 69 64 6d 76 ......3k 4w2uidmv
00000020  76 79 78 2b 53 33 63 72  33 74 20 69 50 61 64 00 vyx+S3cr 3t iPad.
00000030  07 d0 00 01 00 00 00 00  0c ca 7e 2c 00 00 00 00 ........ ..~,....
    00000035  07 d0 00 01 00 00 00 00  0c ca 7e 2c 00 00 00 00 ........ ..~,....
    00000045  08 98 00 00 00 00 00 00  2d c3 47 ff 00 00 00 01 ........ -.G.....
00000040  08 98 00 01 00 00 00 00  f0 55 9e 7a 00 00 00 01 ........ .U.z....
00000050  08 34 00 00 00 00 00 f1  86 bb 03 00 00 00 00 01 .4...... ........
00000060  62 70 6c 69 73 74 30 30  d4 01 02 03 04 05 06 07 bplist00 ........
00000070  08 5f 10 1a 4d 43 4e 65  61 72 62 79 53 65 72 76 ._..MCNe arbyServ
00000080  69 63 65 49 6e 76 69 74  65 49 44 4b 65 79 5f 10 iceInvit eIDKey_.
00000090  21 4d 43 4e 65 61 72 62  79 53 65 72 76 69 63 65 !MCNearb yService
000000A0  52 65 63 69 70 69 65 6e  74 50 65 65 72 49 44 4b Recipien tPeerIDK
000000B0  65 79 5f 10 1b 4d 43 4e  65 61 72 62 79 53 65 72 ey_..MCN earbySer
000000C0  76 69 63 65 4d 65 73 73  61 67 65 49 44 4b 65 79 viceMess ageIDKey
000000D0  5f 10 1e 4d 43 4e 65 61  72 62 79 53 65 72 76 69 _..MCNea rbyServi
000000E0  63 65 53 65 6e 64 65 72  50 65 65 72 49 44 4b 65 ceSender PeerIDKe
000000F0  79 10 00 4f 10 19 31 bc  8d 96 de 00 24 f2 10 69 y..O..1. ....$..i
00000100  50 68 6f 6e 65 20 53 69  6d 75 6c 61 74 6f 72 10 Phone Si mulator.
00000110  01 4f 10 14 ea 0e 27 21  05 e1 7d 99 0b 53 33 63 .O....'! ..}..S3c
00000120  72 33 74 20 69 50 61 64  08 11 2e 52 70 91 93 af r3t iPad ...Rp...
00000130  b1 00 00 00 00 00 00 01  01 00 00 00 00 00 00 00 ........ ........
00000140  09 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 ........ ........
00000150  c8                                               .
    00000055  08 34 00 01 00 00 00 00  73 e2 f9 bb 00 00 00 01 .4...... s.......
    00000065  08 34 00 00 00 00 01 67  08 26 9f a3 00 00 00 02 .4.....g .&......
    00000075  62 70 6c 69 73 74 30 30  d6 01 02 03 04 05 06 07 bplist00 ........
    00000085  08 09 0a 0b 0c 5f 10 20  4d 43 4e 65 61 72 62 79 ....._.  MCNearby
```

6 client pkts, 5 server pkts, 6 turns.


Follow TCP Stream (tcp.stream eq 2)

```
    00000000  07 d0 00 00 00 00 00 25  a8 43 58 93 00 00 00 00 .......% .CX.....
    00000010  00 00 00 06 00 1f 30 72  38 38 67 72 7a 76 63 71 ......0r 88grzvcq
    00000020  65 70 65 2b 69 50 68 6f  6e 65 20 53 69 6d 75 6c epe+iPho ne Simul
    00000030  61 74 6f 72 00                                   ator.
00000000  07 d0 00 00 00 00 00 20  49 cd 68 0a 00 00 00 00 .......  I.h.....
00000010  00 00 00 06 00 1a 33 6b  34 77 32 75 69 64 6d 76 ......3k 4w2uidmv
00000020  76 79 78 2b 53 33 63 72  33 74 20 69 50 61 64 00 vyx+S3cr 3t iPad.
00000030  07 d0 00 01 00 00 00 00  0c ca 7e 2c 00 00 00 00 ........ ..~,....
    00000035  07 d0 00 01 00 00 00 00  0c ca 7e 2c 00 00 00 00 ........ ..~,....
    00000045  08 98 00 00 00 00 00 00  2d c3 47 ff 00 00 00 01 ........ -.G.....
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00000070  08 5f 10 1a 4d 43 4e 65  61 72 62 79 53 65 72 76 ._..MCNe arbyServ
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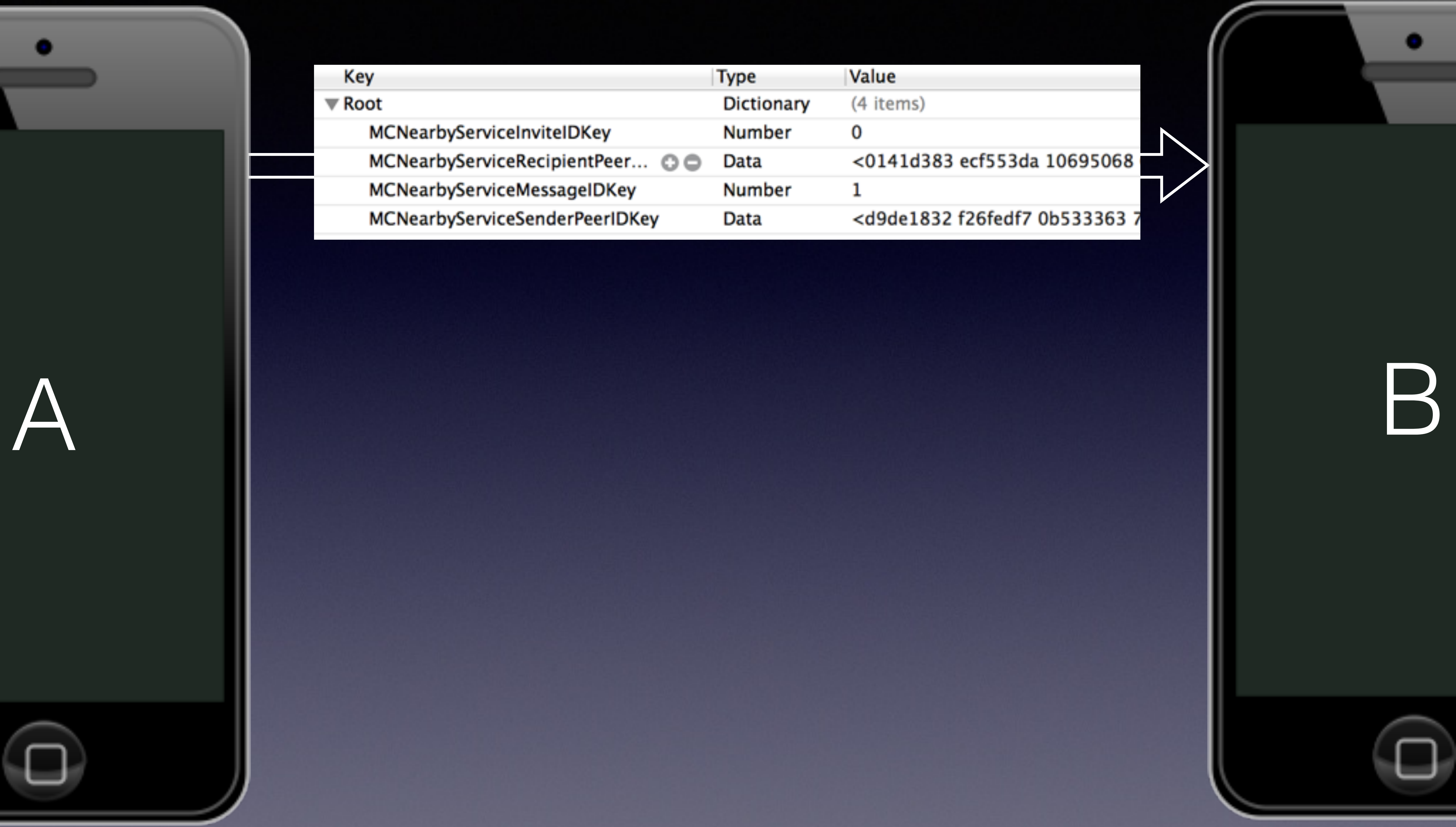
00000090  21 4d 43 4e 65 61 72 62  79 53 65 72 76 69 63 65 !MCNearb yService
000000A0  52 65 63 69 70 69 65 6e  74 50 65 65 72 49 44 4b Recipien tPeerIDK
000000B0  65 79 5f 10 1b 4d 43 4e  65 61 72 62 79 53 65 72 ey_..MCN earbySer
000000C0  76 69 63 65 4d 65 73 73  61 67 65 49 44 4b 65 79 viceMess ageIDKey
000000D0  5f 10 1e 4d 43 4e 65 61  72 62 79 53 65 72 76 69 _..MCNea rbyServi
000000E0  63 65 53 65 6e 64 65 72  50 65 65 72 49 44 4b 65 ceSender PeerIDKe
000000F0  79 10 00 4f 10 19 31 bc  8d 96 de 00 24 f2 10 69 y..O..1. ....$..i
00000100  50 68 6f 6e 65 20 53 69  6d 75 6c 61 74 6f 72 10 Phone Si mulator.
00000110  01 4f 10 14 ea 0e 27 21  05 e1 7d 99 0b 53 33 63 .O....'! ..}..S3c
00000120  72 33 74 20 69 50 61 64  08 11 2e 52 70 91 93 af r3t iPad ...Rp...
00000130  b1 00 00 00 00 00 00 01  01 00 00 00 00 00 00 00 ........ ........
00000140  09 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 ........ ........
00000150  c8                                               .
    00000055  08 34 00 01 00 00 00 00  73 e2 f9 bb 00 00 00 01 .4...... s.......
    00000065  08 34 00 00 00 00 01 67  08 26 9f a3 00 00 00 02 .4.....g .&......
    00000075  62 70 6c 69 73 74 30 30  d6 01 02 03 04 05 06 07 bplist00 ........
    00000085  08 09 0a 0b 0c 5f 10 20  4d 43 4e 65 61 72 62 79 ....._.  MCNearby
```

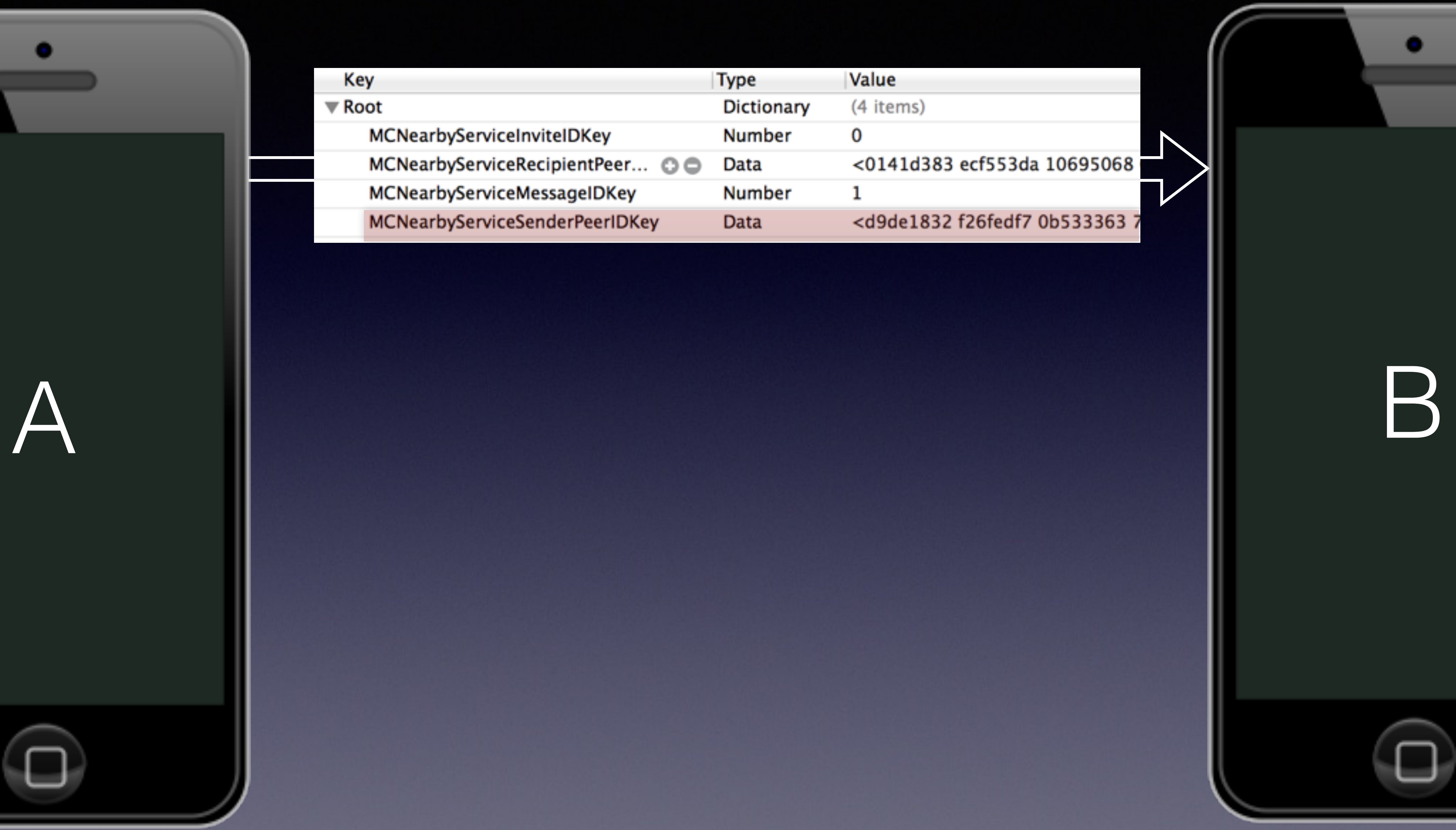
6 client pkts, 5 server pkts, 6 turns.

Mystery Protocol #1

- Peer connects to the other peer over TCP
- Each peer sends their “PeerID” first
    - (random) “idString” + device name
    - For example: ”ory2g6r8fkq+iPhone Simulator”
- Three plists are then exchanged



Key	Type	Value
▼ Root	Dictionary	(4 items)
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceRecipientPeer...	Data	<0141d383 ecf553da 10695068
MCNearbyServiceMessageIDKey	Number	1
MCNearbyServiceSenderPeerIDKey	Data	<d9de1832 f26fedf7 0b533363 7



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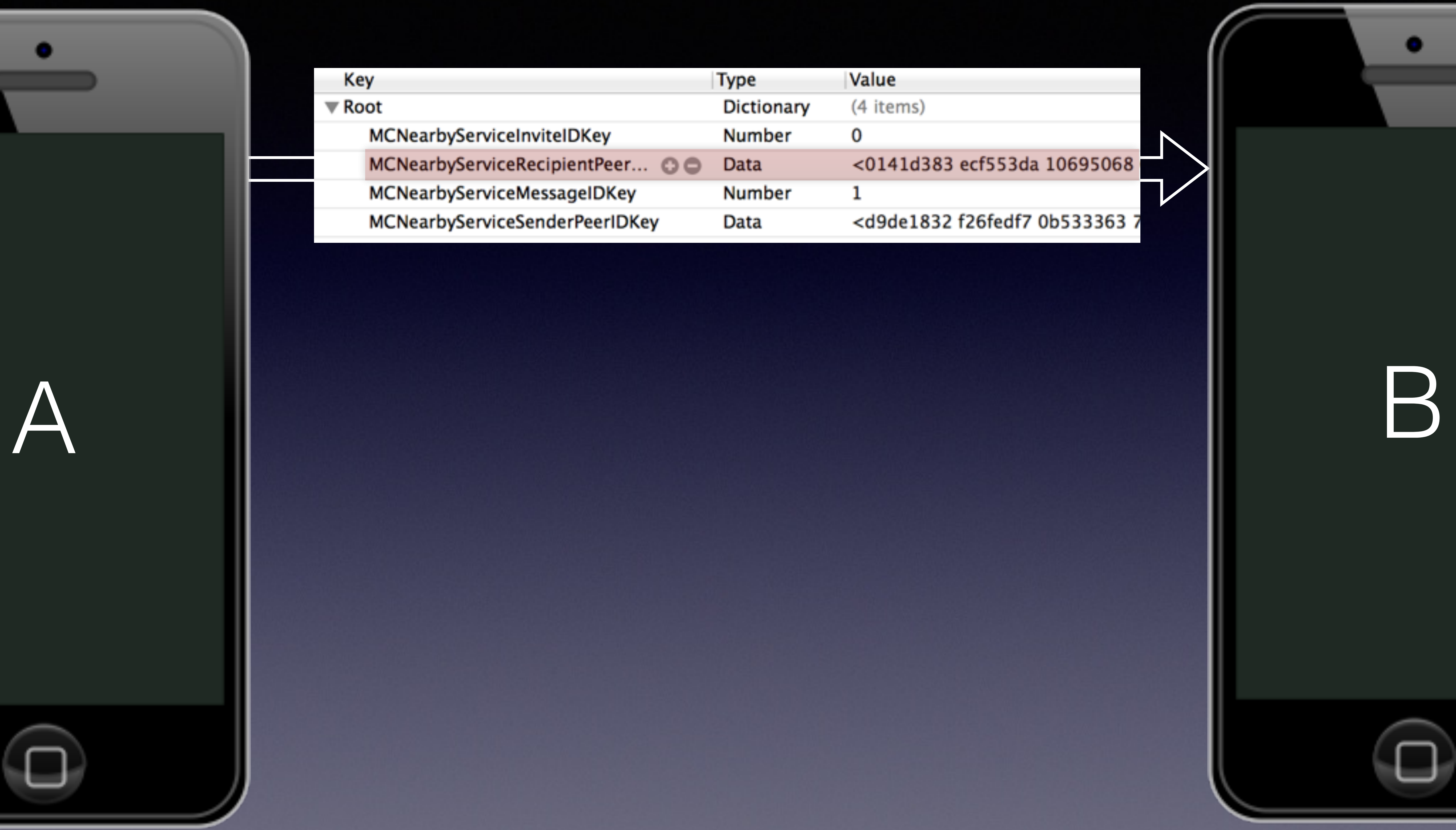

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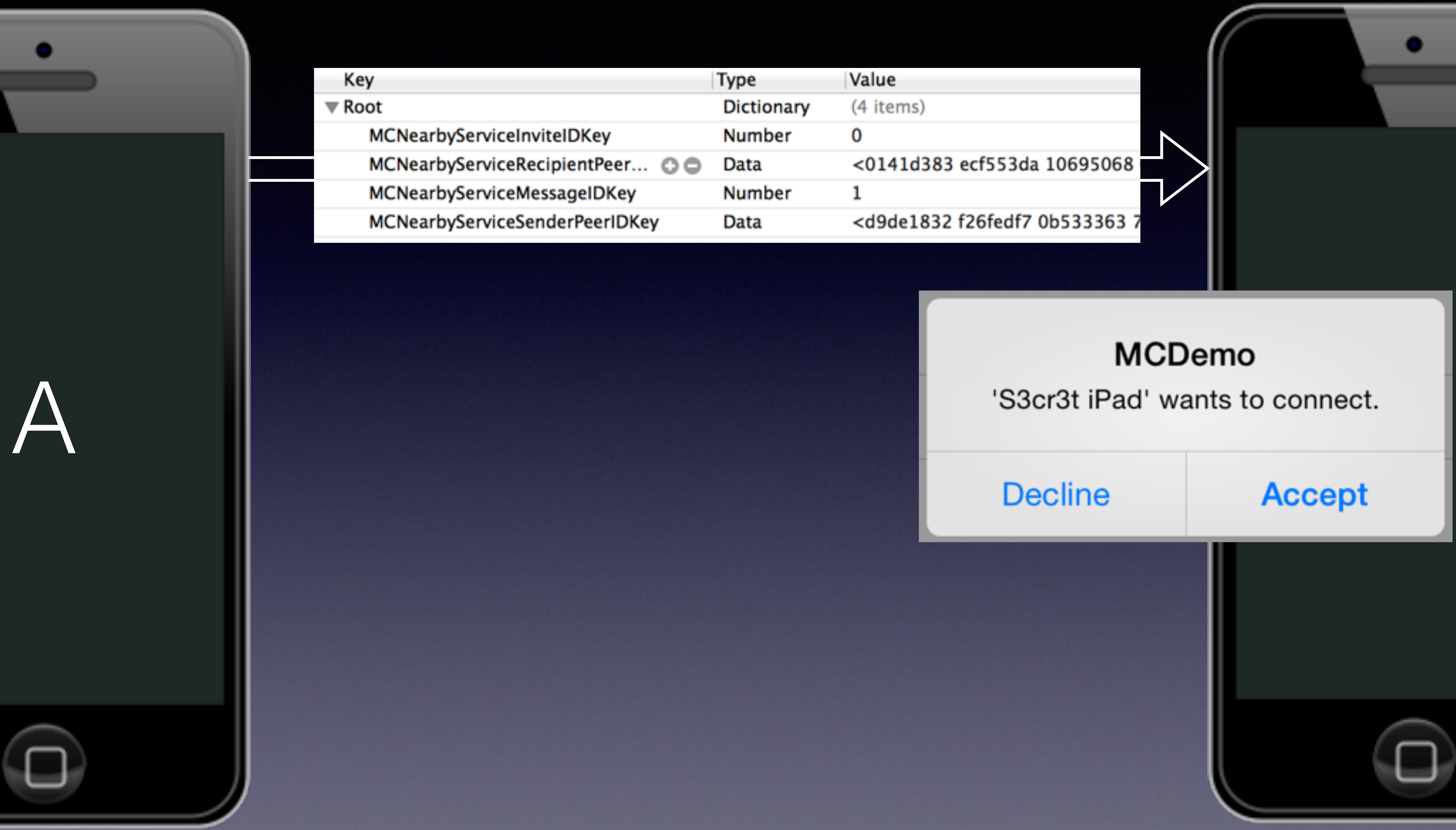

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MCNearbyServiceRecipientPeer...	Data	<0141d383 ecf553da 10695068
MCNearbyServiceMessageIDKey	Number	1
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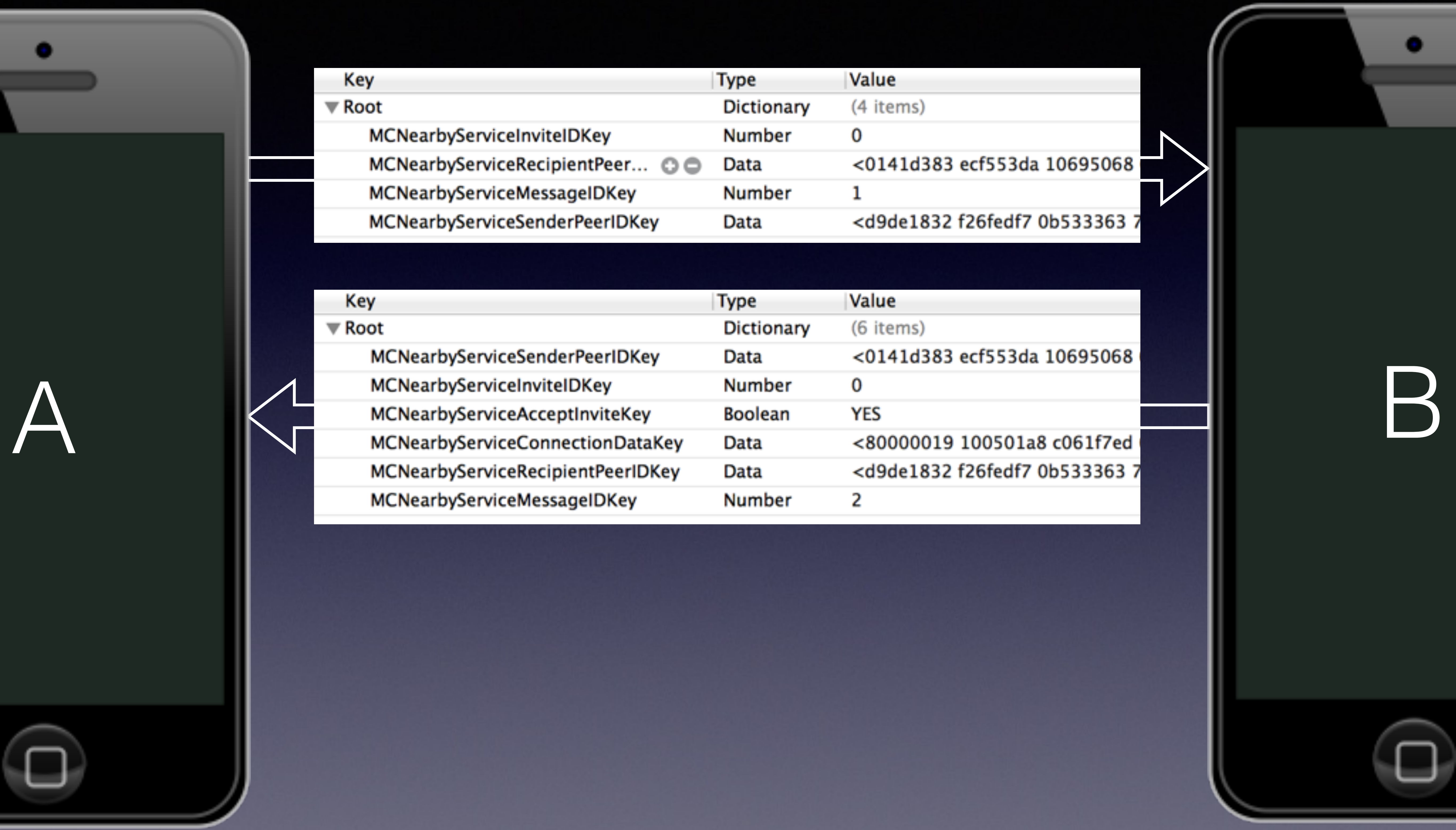
MCDemo

'S3cr3t iPad' wants to connect.



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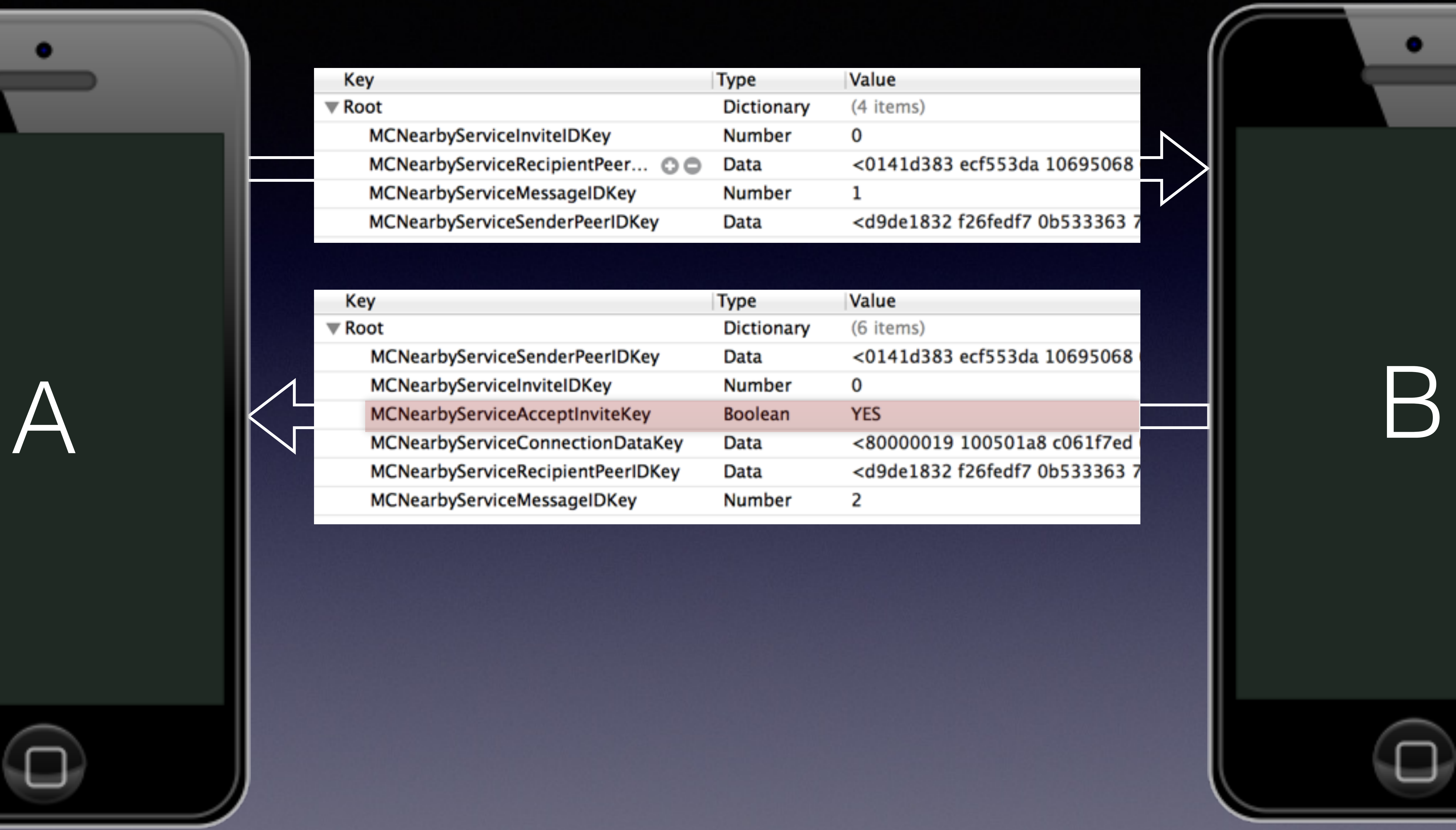
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceRecipientPeer…	Data	<0141d383 ecf553da 10695068
MCNearbyServiceMessageIDKey	Number	1
MCNearbyServiceSenderPeerIDKey	Data	<d9de1832 f26fedf7 0b533363 7

Key	Type	Value
▼ Root	Dictionary	(6 items)
MCNearbyServiceSenderPeerIDKey	Data	<0141d383 ecf553da 10695068
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceAcceptInviteKey	Boolean	YES
MCNearbyServiceConnectionDataKey	Data	<80000019 100501a8 c061f7ed
MCNearbyServiceRecipientPeerIDKey	Data	<d9de1832 f26fedf7 0b533363 7
MCNearbyServiceMessageIDKey	Number	2



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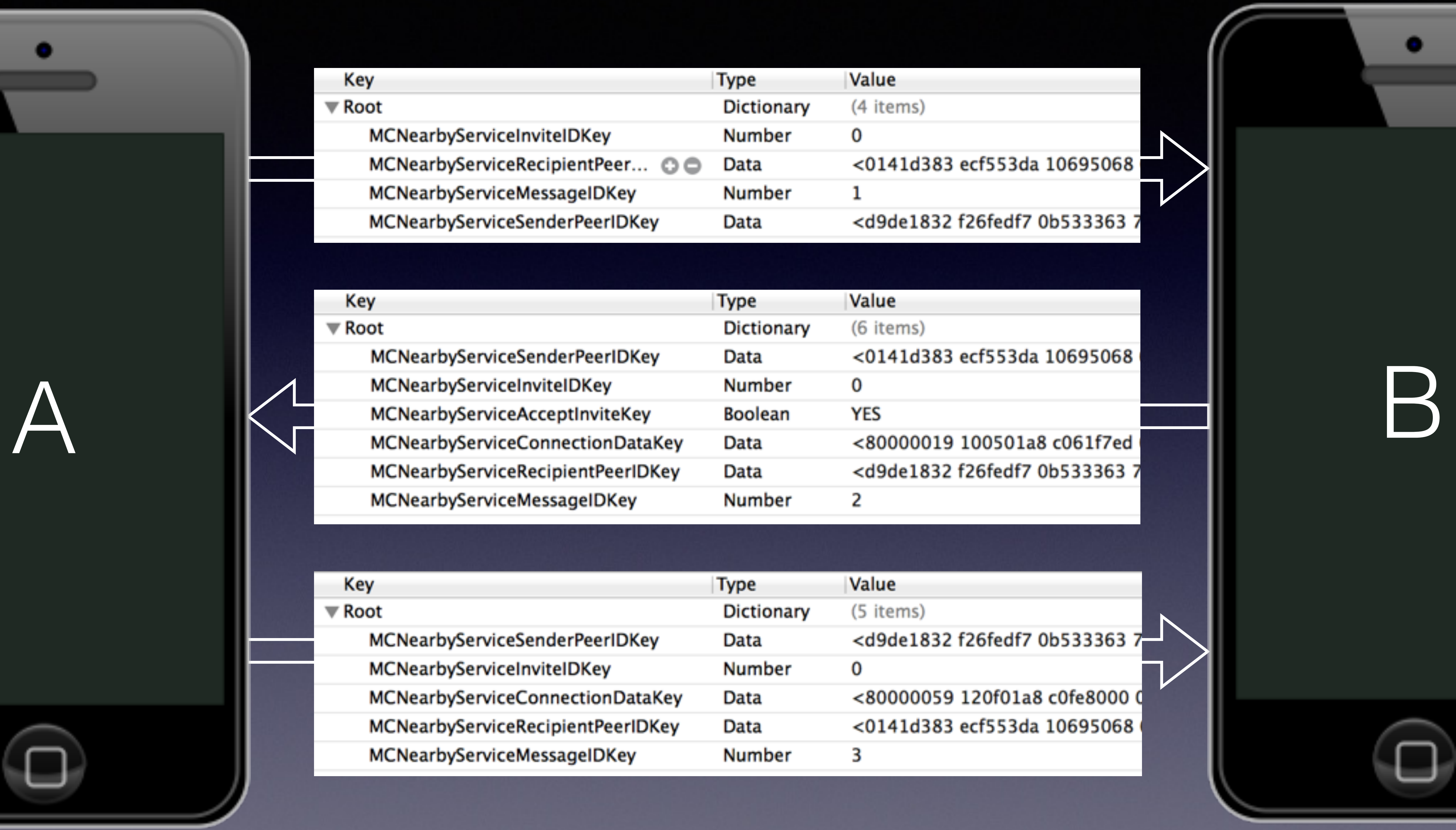
MCNearbyServiceMessageIDKey	Number	1
MCNearbyServiceSenderPeerIDKey	Data	<d9de1832 f26fedf7 0b533363 7

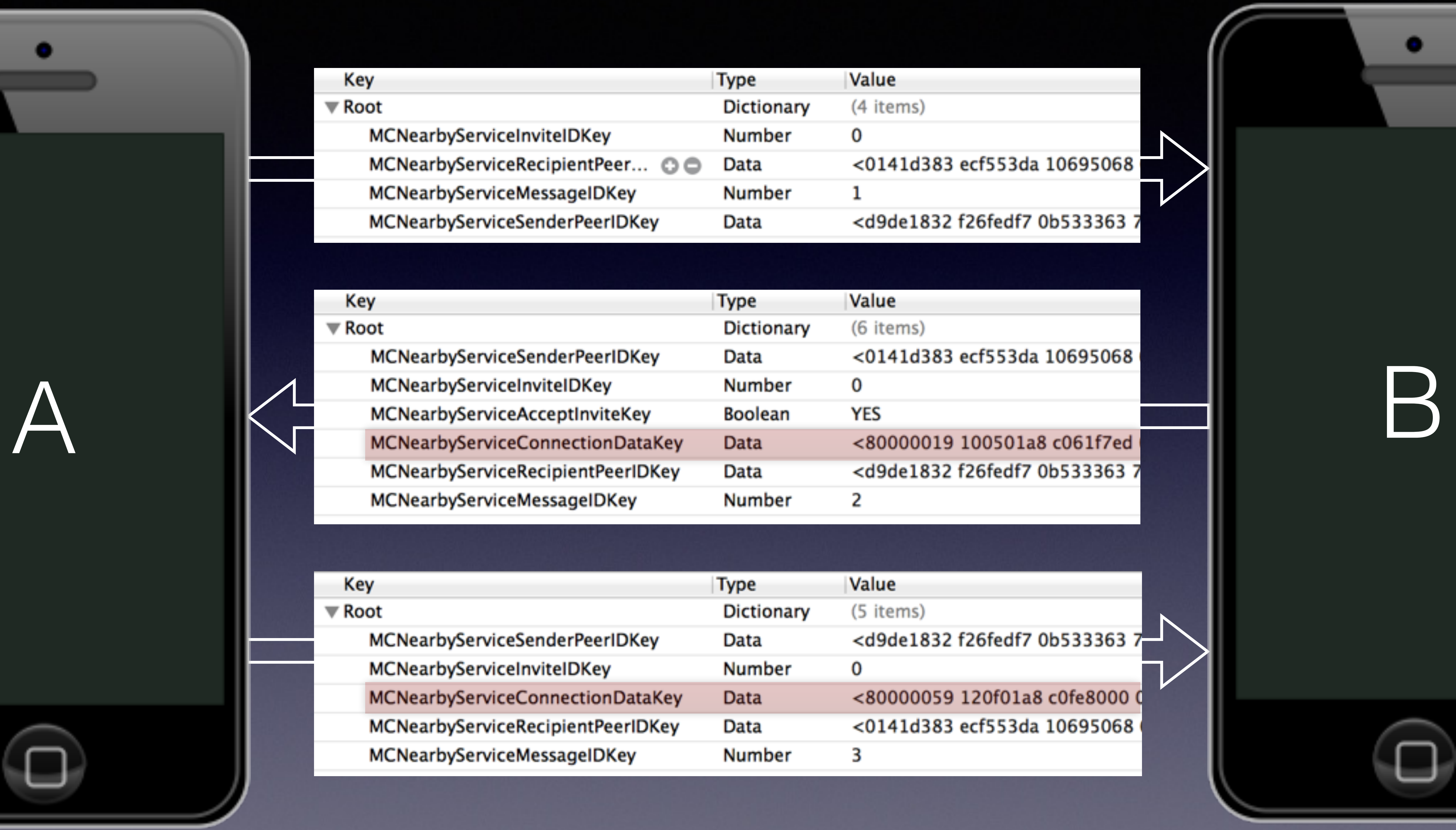
Key	Type	Value
▼ Root	Dictionary	(6 items)
MCNearbyServiceSenderPeerIDKey	Data	<0141d383 ecf553da 10695068
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceAcceptInviteKey	Boolean	YES
MCNearbyServiceConnectionDataKey	Data	<80000019 100501a8 c061f7ed
MCNearbyServiceRecipientPeerIDKey	Data	<d9de1832 f26fedf7 0b533363 7
MCNearbyServiceMessageIDKey	Number	2



Key	Type	Value
▼ Root	Dictionary	(4 items)
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceRecipientPeer…	Data	<0141d383 ecf553da 10695068
MCNearbyServiceMessageIDKey	Number	1
MCNearbyServiceSenderPeerIDKey	Data	<d9de1832 f26fedf7 0b533363 7

Key	Type	Value
▼ Root	Dictionary	(6 items)
MCNearbyServiceSenderPeerIDKey	Data	<0141d383 ecf553da 10695068
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceAcceptInviteKey	Boolean	YES
MCNearbyServiceConnectionDataKey	Data	<80000019 100501a8 c061f7ed
MCNearbyServiceRecipientPeerIDKey	Data	<d9de1832 f26fedf7 0b533363 7
MCNearbyServiceMessageIDKey	Number	2

Key	Type	Value
▼ Root	Dictionary	(5 items)
MCNearbyServiceSenderPeerIDKey	Data	<d9de1832 f26fedf7 0b533363 7
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceConnectionDataKey	Data	<80000059 120f01a8 c0fe8000
MCNearbyServiceRecipientPeerIDKey	Data	<0141d383 ecf553da 10695068
MCNearbyServiceMessageIDKey	Number	3



Key	Type	Value
▼ Root	Dictionary	(4 items)
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceRecipientPeer…	Data	<0141d383 ecf553da 10695068
MCNearbyServiceMessageIDKey	Number	1
MCNearbyServiceSenderPeerIDKey	Data	<d9de1832 f26fedf7 0b533363

Key	Type	Value
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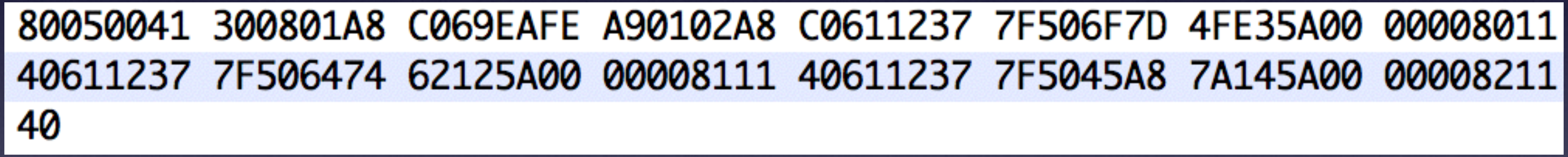
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceAcceptInviteKey	Boolean	YES
MCNearbyServiceConnectionDataKey	Data	<80000019 100501a8 c061f7ed
MCNearbyServiceRecipientPeerIDKey	Data	<d9de1832 f26fedf7 0b533363
MCNearbyServiceMessageIDKey	Number	2

Key	Type	Value
▼ Root	Dictionary	(5 items)
MCNearbyServiceSenderPeerIDKey	Data	<d9de1832 f26fedf7 0b533363
MCNearbyServiceInviteIDKey	Number	0
MCNearbyServiceConnectionDataKey	Data	<80000059 120f01a8 c0fe8000
MCNearbyServiceRecipientPeerIDKey	Data	<0141d383 ecf553da 10695068
MCNearbyServiceMessageIDKey	Number	3

Mystery Protocol #1

- Each peer exchanges their **MCNearbyConnectionDataKey**
  - Main "payload" of the protocol; briefly mentioned as “connection data” in the documentation



```
80050041 300801A8 C069EAFE A90102A8 C0611237 7F506F7D 4FE35A00 00008011
40611237 7F506474 62125A00 00008111 40611237 7F5045A8 7A145A00 00008211
40
```

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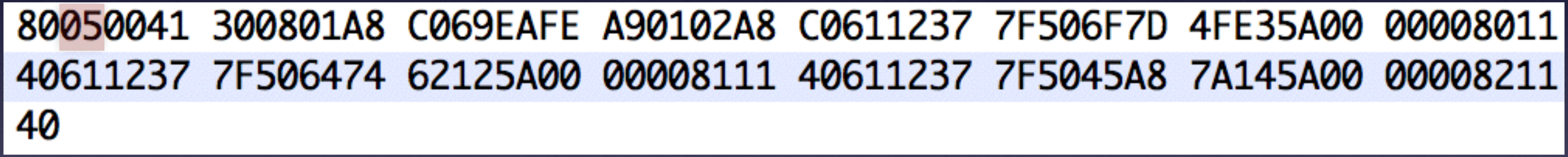

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80050041 300801A8 C069EAFE A90102A8 C0611237 7F506F7D 4FE35A00 00008011
40611237 7F506474 62125A00 00008111 40611237 7F5045A8 7A145A00 00008211
40
```

- The peer’s security settings as bit fields:
    - Encryption level (optional = X00, none = X10, required = X01)
    - Whether authentication is enabled (yes = 1XX, no = 0XX)
        - Only the settings; no X509 certificate/identity yet

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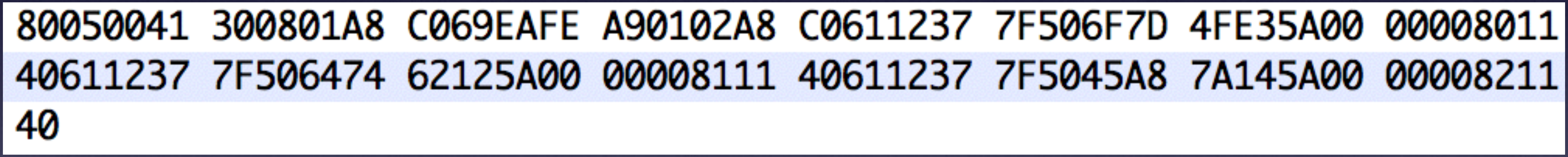

```
80050041 300801A8 C069EAFE A90102A8 C0611237 7F506F7D 4FE35A00 00008011
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- Then a list of local "candidate" IP addresses and port numbers

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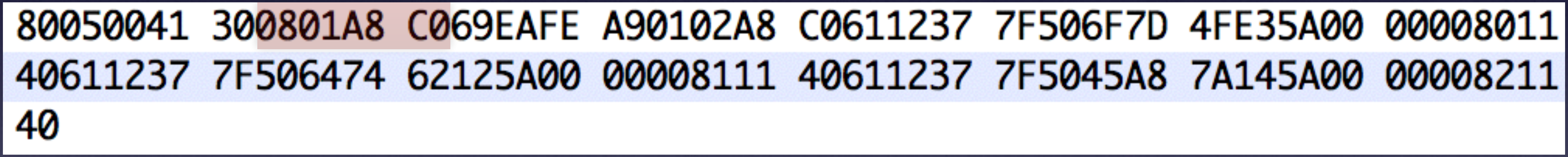

```
80050041 300801A8 C069EAFE A90102A8 C0611237 7F506F7D 4FE35A00 00008011
40611237 7F506474 62125A00 00008111 40611237 7F5045A8 7A145A00 00008211
40
```

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  - 192.168.1.8

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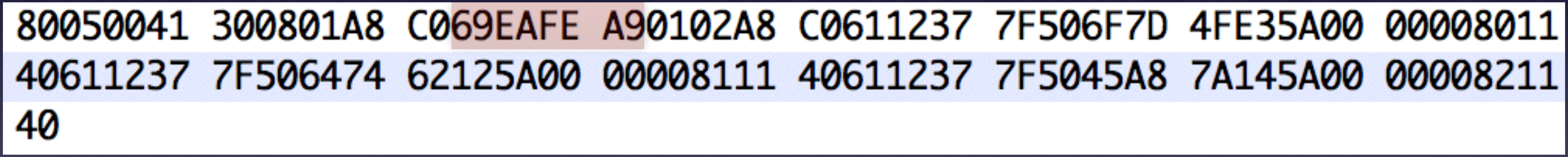

```
80050041 300801A8 C069EAFE A90102A8 C0611237 7F506F7D 4FE35A00 00008011
40611237 7F506474 62125A00 00008111 40611237 7F5045A8 7A145A00 00008211
40
```

- Then a list of local "candidate" IP addresses and port numbers
  - 192.168.1.8
  - 169.254.234.105
  - Etc…

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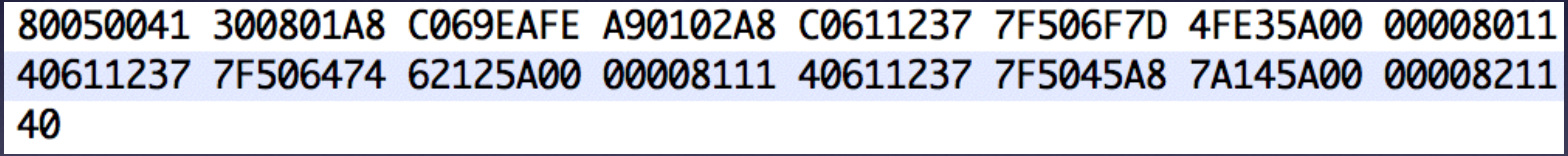

```
80050041 300801A8 C069EAFE A90102A8 C0611237 7F506F7D 4FE35A00 00008011
40611237 7F506474 62125A00 00008111 40611237 7F5045A8 7A145A00 00008211
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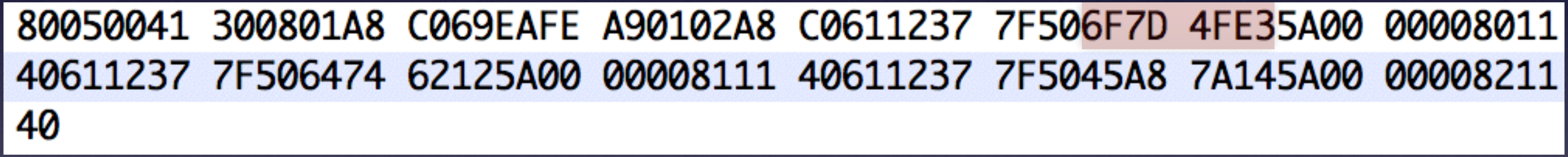
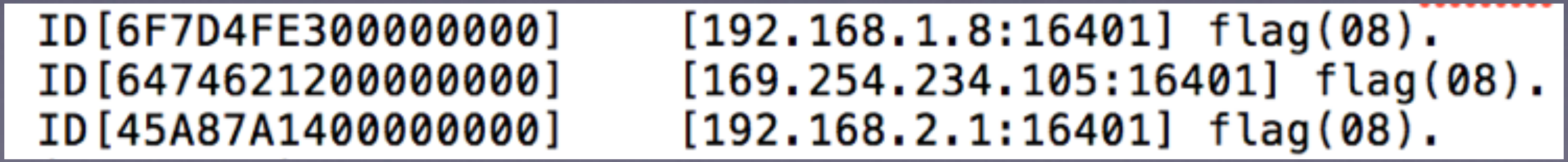
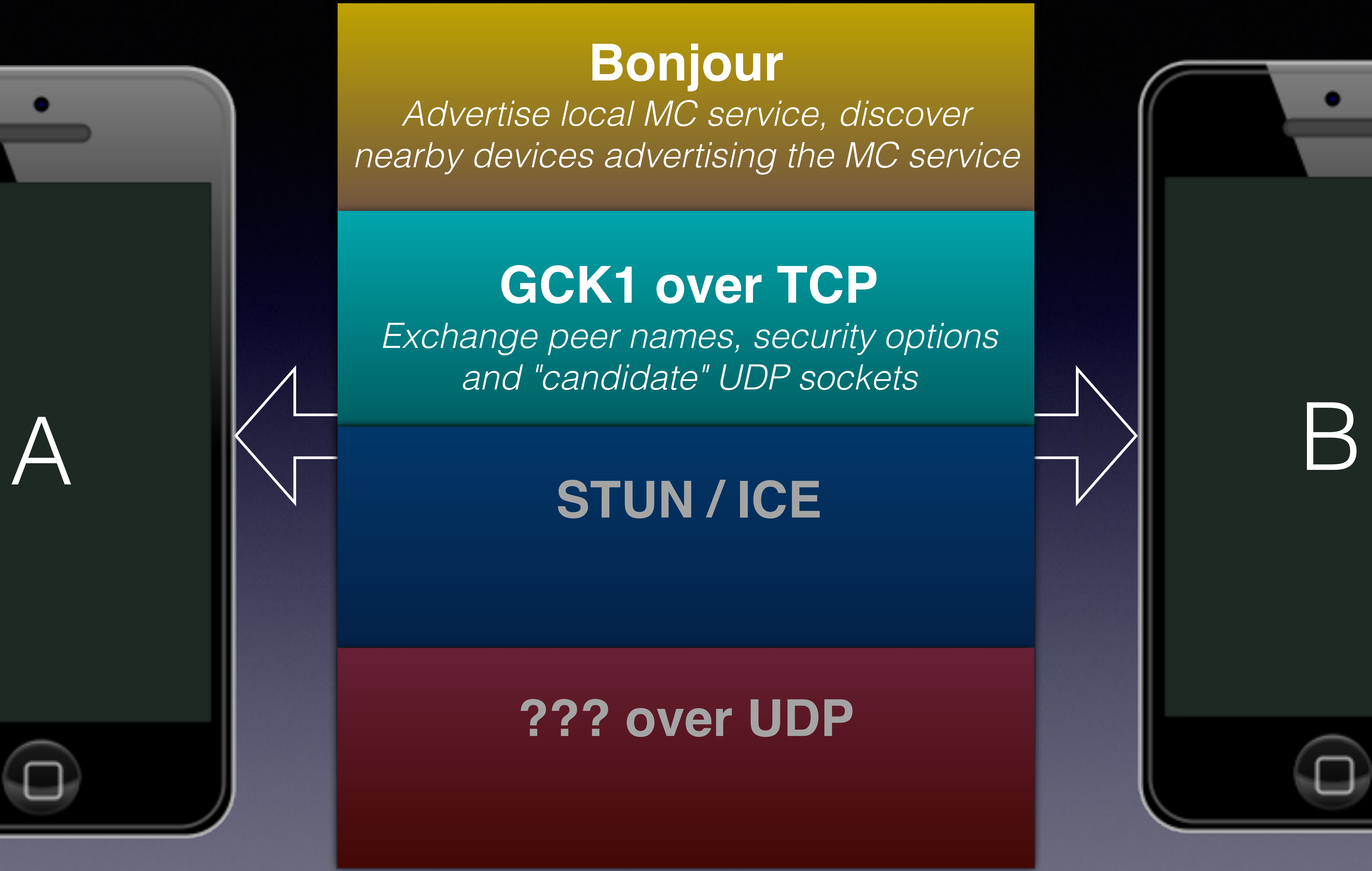


```
80050041 300801A8 C069EAFE A90102A8 C0611237 7F506F7D 4FE35A00 00008011
40611237 7F506474 62125A00 00008111 40611237 7F5045A8 7A145A00 00008211
40
```

- Then some kind of IDs (according to debug logs)?
    - 6F7D4FE3, etc…



```
ID[6F7D4FE300000000]     [192.168.1.8:16401] flag(08).
ID[6474621200000000]     [169.254.234.105:16401] flag(08).
ID[45A87A1400000000]     [192.168.2.1:16401] flag(08).
```



Bonjour

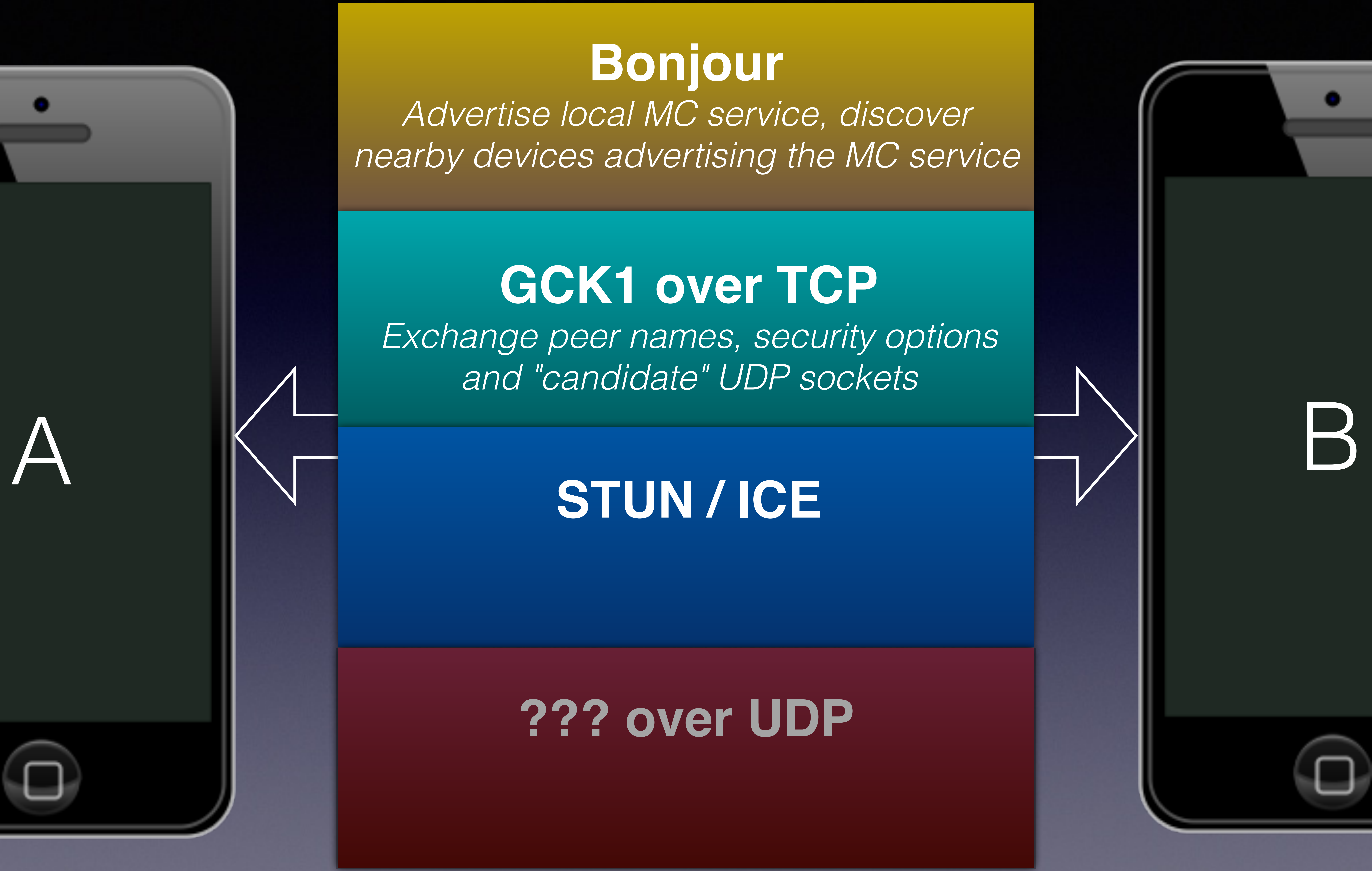
Advertise local MC service, discover nearby devices advertising the MC service

GCK1 over TCP

Exchange peer names, security options and "candidate" UDP sockets

STUN / ICE

??? over UDP



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??? over UDP

Interactive Connectivy Establishement

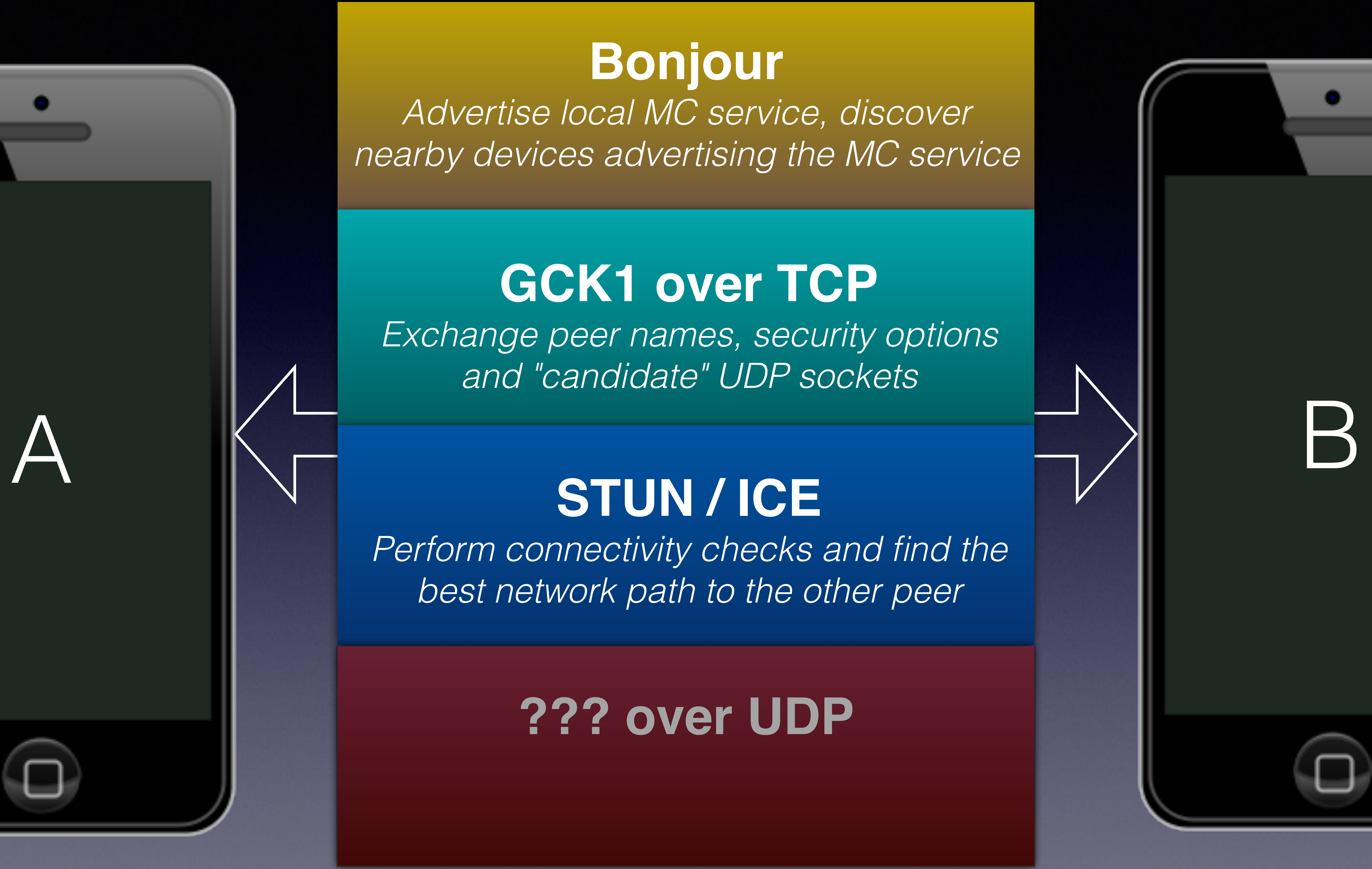
```
com.apple.MultipeerConnectivity: GK START ICE check with peer 317456B5
com.apple.ICE: Updated ICEList(829707957) to role (1)

com.apple.ICE: Local candidate(1/3):   ID[07FEE53F00000000]  [192.168.2.2:16402]
com.apple.ICE: Local candidate(2/3):   ID[4348FA0000000000]  [[fe80::29:203:1454:aa5a%en0]:16402]
com.apple.ICE: Local candidate(3/3):   ID[3904EA8D00000000]  [[fe80::ecf1:14ff:fe49:d55a%awdl0]:16402]

com.apple.ICE: Remote candidate(1/3):  ID[6F7D4FE300000000]  [192.168.1.8:16401]
com.apple.ICE: Remote candidate(2/3):  ID[6474621200000000]  [169.254.234.105:16401]
com.apple.ICE: Remote candidate(3/3):  ID[45A87A1400000000]  [192.168.2.1:16401]

com.apple.ICE: ICEStartConnectivityCheck(id[local:829707957 remote:1350514450] count[local:3 remote:3]
com.apple.ICE: [CHECKPOINT] connectivity-check-thread-started
com.apple.ICE:    event 192.168.2.2:16402->192.168.1.8:16401 expires 210041.818916


com.apple.ICE: ** BINDING_REQUEST [00018674C3972B2DC739DF77] from [192.168.1.8:16401] USERNAME
[07FEE53F.00000000.1-6F7D4FE3.00000000.1]
com.apple.ICE: Remote ICE Version: 109
com.apple.ICE:     OLD STATE(TESTING)->NEW STATE(TESTING)
com.apple.MultipeerConnectivity: send udp packet from 192.168.2.2:16402 to 192.168.1.8:16401 ...
```



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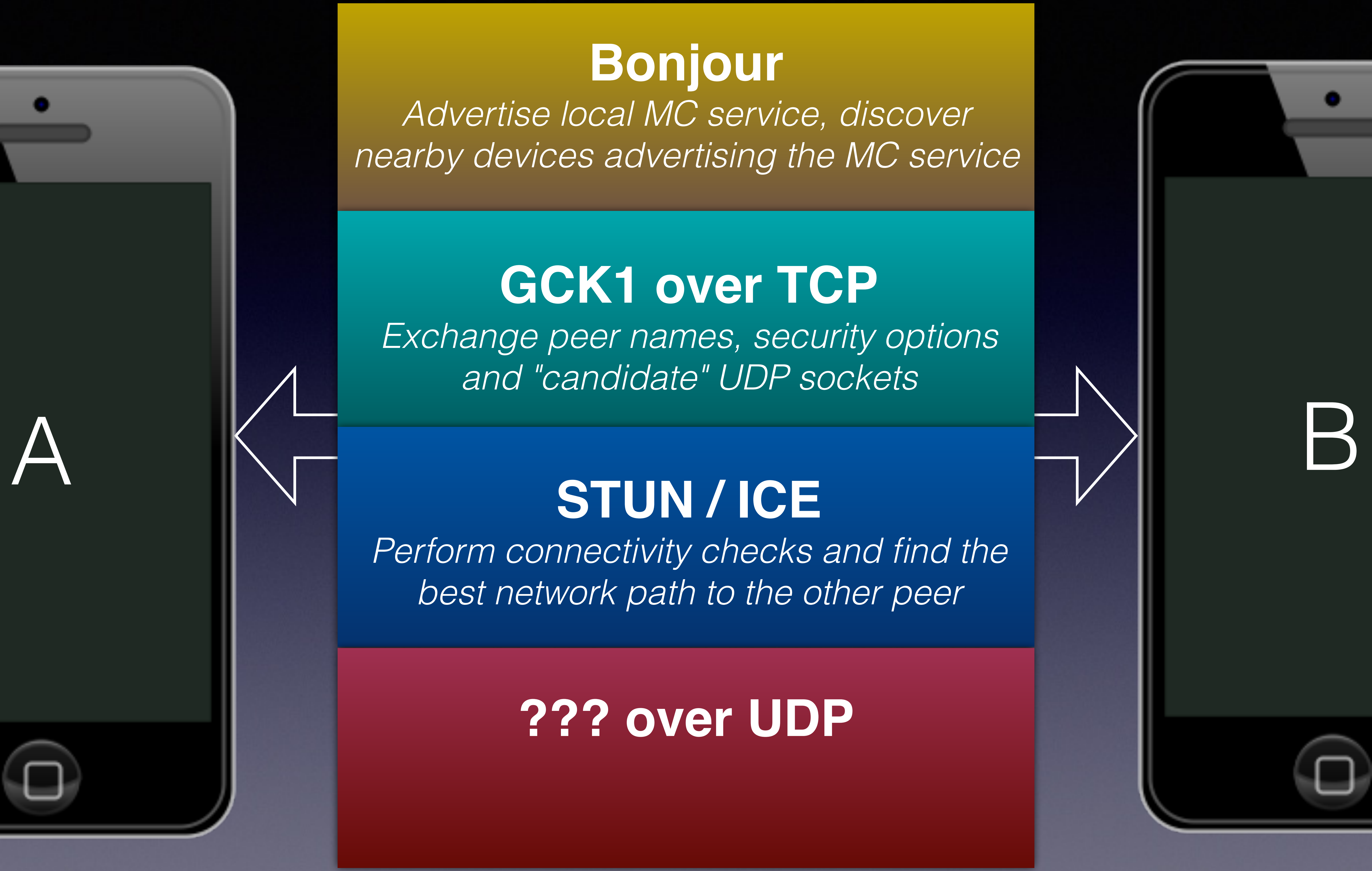

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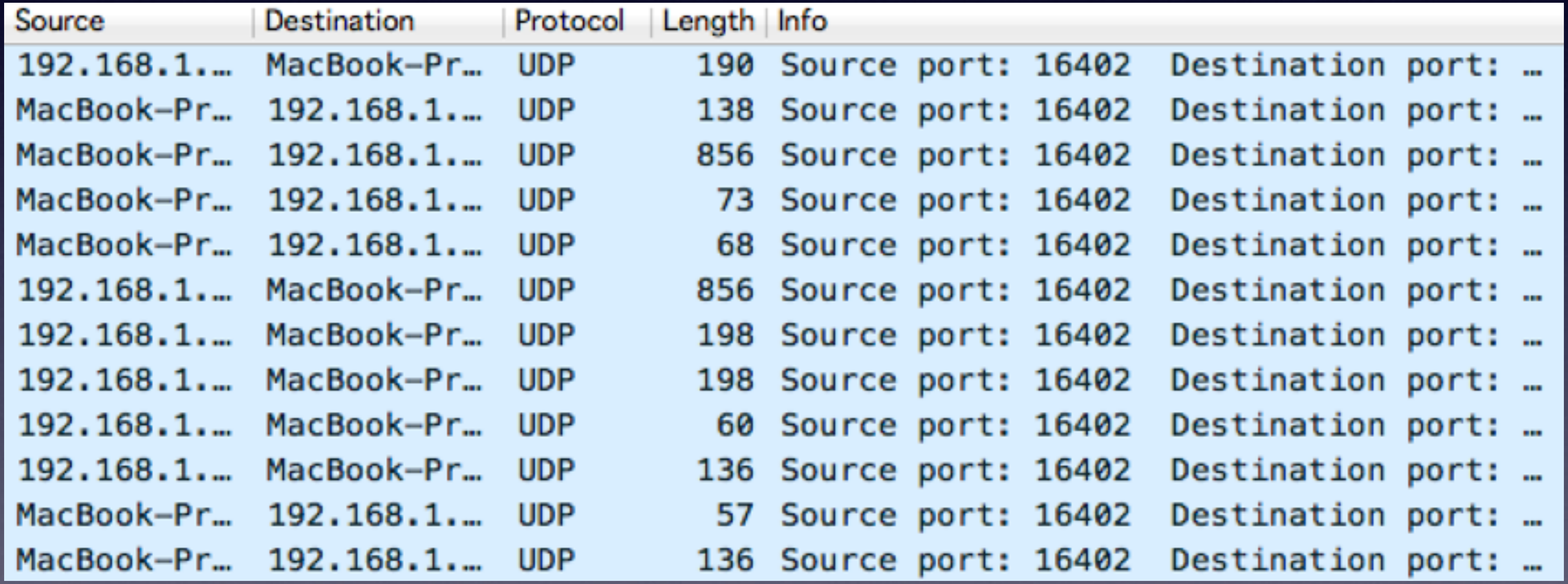
Mystery Protocol #2



Source	Destination	Protocol	Length	Info
192.168.1.…	MacBook-Pr…	UDP	190	Source port: 16402 Destination port: …
MacBook-Pr…	192.168.1.…	UDP	138	Source port: 16402 Destination port: …
MacBook-Pr…	192.168.1.…	UDP	856	Source port: 16402 Destination port: …
MacBook-Pr…	192.168.1.…	UDP	73	Source port: 16402 Destination port: …
MacBook-Pr…	192.168.1.…	UDP	68	Source port: 16402 Destination port: …
192.168.1.…	MacBook-Pr…	UDP	856	Source port: 16402 Destination port: …
192.168.1.…	MacBook-Pr…	UDP	198	Source port: 16402 Destination port: …
192.168.1.…	MacBook-Pr…	UDP	198	Source port: 16402 Destination port: …
192.168.1.…	MacBook-Pr…	UDP	60	Source port: 16402 Destination port: …
192.168.1.…	MacBook-Pr…	UDP	136	Source port: 16402 Destination port: …
MacBook-Pr…	192.168.1.…	UDP	57	Source port: 16402 Destination port: …
MacBook-Pr…	192.168.1.…	UDP	136	Source port: 16402 Destination port: …

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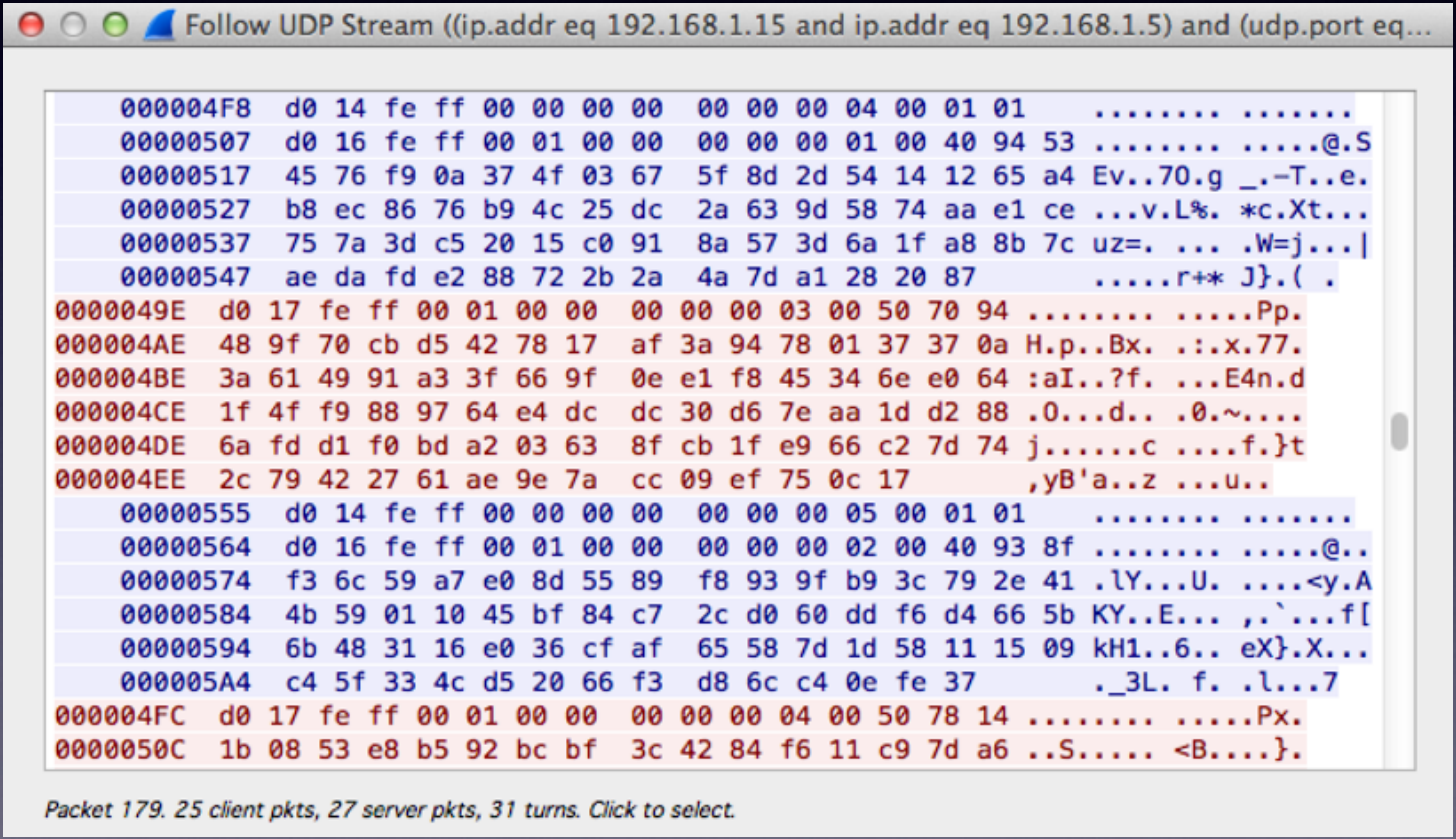

Follow UDP Stream ((ip.addr eq 192.168.1.15 and ip.addr eq 192.168.1.5) and (udp.port eq...

```
    000004F8  d0 14 fe ff 00 00 00 00  00 00 00 04 00 01 01    ........ .......
    00000507  d0 16 fe ff 00 01 00 00  00 00 00 01 00 40 94 53 ........ .....@.S
    00000517  45 76 f9 0a 37 4f 03 67  5f 8d 2d 54 14 12 65 a4 Ev..7O.g _.-T..e.
    00000527  b8 ec 86 76 b9 4c 25 dc  2a 63 9d 58 74 aa e1 ce ...v.L%. *c.Xt...
    00000537  75 7a 3d c5 20 15 c0 91  8a 57 3d 6a 1f a8 8b 7c uz=. ... .W=j...|
    00000547  ae da fd e2 88 72 2b 2a  4a 7d a1 28 20 87       .....r+* J}.( .
0000049E  d0 17 fe ff 00 01 00 00  00 00 00 03 00 50 70 94 ........ .....Pp.
000004AE  48 9f 70 cb d5 42 78 17  af 3a 94 78 01 37 37 0a H.p..Bx. .:.x.77.
000004BE  3a 61 49 91 a3 3f 66 9f  0e e1 f8 45 34 6e e0 64 :aI..?f. ...E4n.d
000004CE  1f 4f f9 88 97 64 e4 dc  dc 30 d6 7e aa 1d d2 88 .O...d.. .0.~....
000004DE  6a fd d1 f0 bd a2 03 63  8f cb 1f e9 66 c2 7d 74 j......c ....f.}t
000004EE  2c 79 42 27 61 ae 9e 7a  cc 09 ef 75 0c 17       ,yB'a..z ...u..
    00000555  d0 14 fe ff 00 00 00 00  00 00 00 05 00 01 01    ........ .......
    00000564  d0 16 fe ff 00 01 00 00  00 00 00 02 00 40 93 8f ........ .....@..
    00000574  f3 6c 59 a7 e0 8d 55 89  f8 93 9f b9 3c 79 2e 41 .lY...U. ....<y.A
    00000584  4b 59 01 10 45 bf 84 c7  2c d0 60 dd f6 d4 66 5b KY..E... ,.`...f[
    00000594  6b 48 31 16 e0 36 cf af  65 58 7d 1d 58 11 15 09 kH1..6.. eX}.X...
    000005A4  c4 5f 33 4c d5 20 66 f3  d8 6c c4 0e fe 37       ._3L. f. .l...7
000004FC  d0 17 fe ff 00 01 00 00  00 00 00 04 00 50 78 14 ........ .....Px.
0000050C  1b 08 53 e8 b5 92 bc bf  3c 42 84 f6 11 c9 7d a6 ..S..... <B....}.
```

Packet 179. 25 client pkts, 27 server pkts, 31 turns. Click to select.

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- It’s the protocol used when App data is being exchanged
- Not plaintext… but Wireshark doesn’t know what it is
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  -
  -

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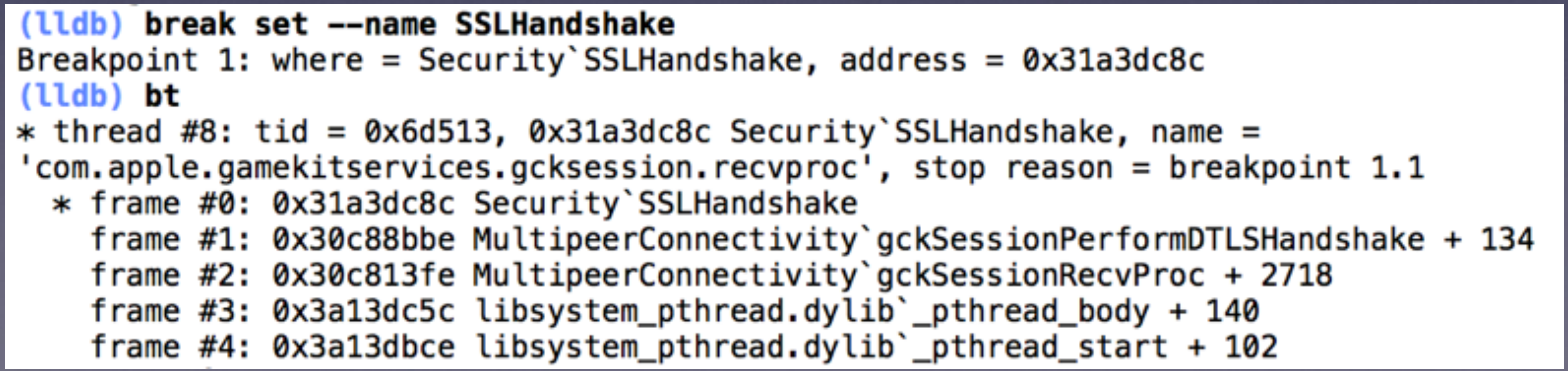

```
(lldb) break set --name SSLHandshake
Breakpoint 1: where = Security`SSLHandshake, address = 0x31a3dc8c
(lldb) bt
* thread #8: tid = 0x6d513, 0x31a3dc8c Security`SSLHandshake, name =
'com.apple.gamekitservices.gcksession.recvproc', stop reason = breakpoint 1.1
  * frame #0: 0x31a3dc8c Security`SSLHandshake
    frame #1: 0x30c88bbe MultipeerConnectivity`gckSessionPerformDTLSHandshake + 134
    frame #2: 0x30c813fe MultipeerConnectivity`gckSessionRecvProc + 2718
    frame #3: 0x3a13dc5c libsystem_pthread.dylib`_pthread_body + 140
    frame #4: 0x3a13dbce libsystem_pthread.dylib`_pthread_start + 102
```

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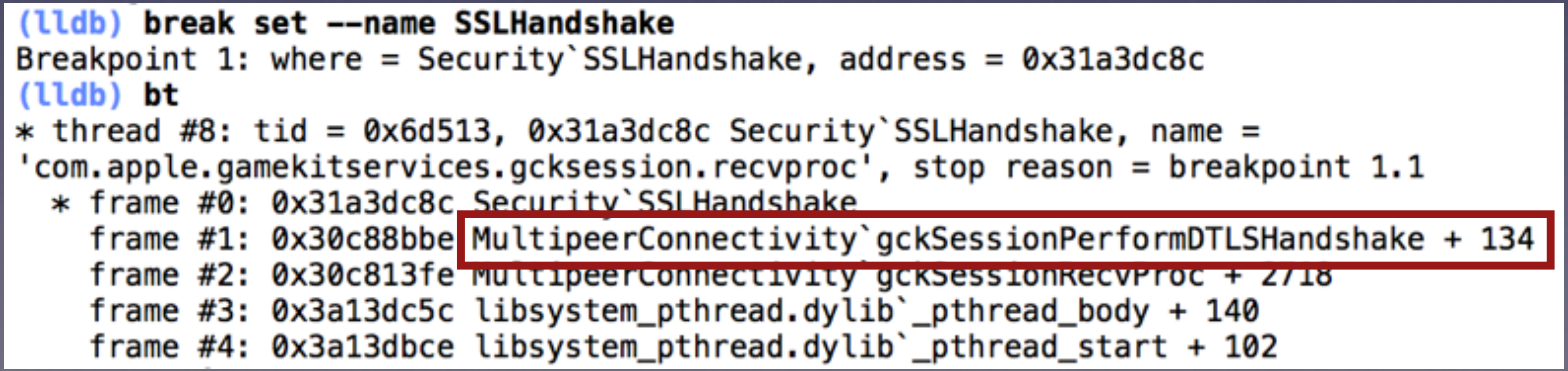

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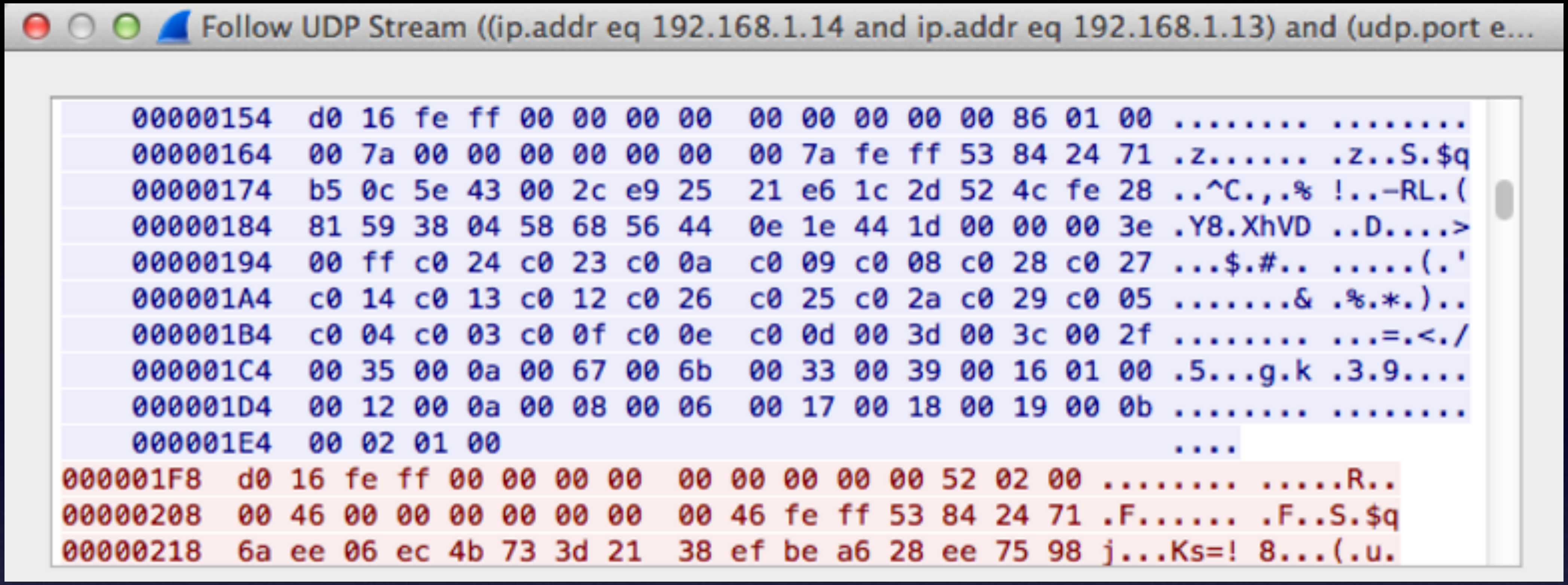
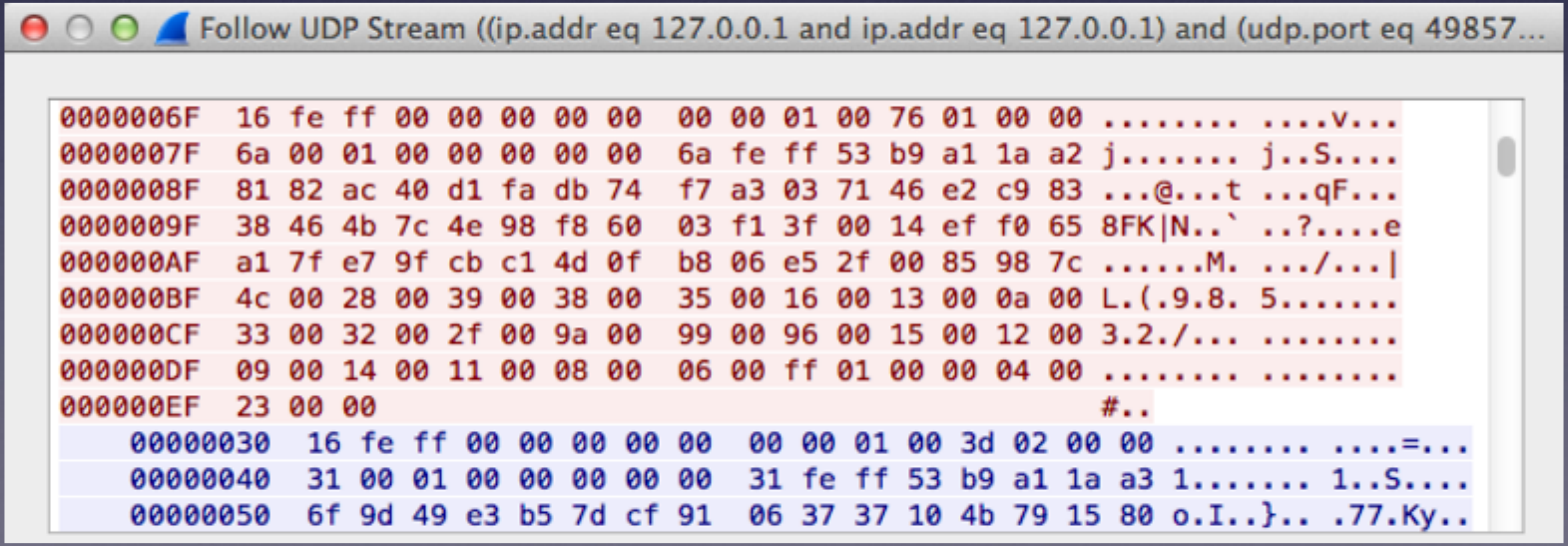


Follow UDP Stream ((ip.addr eq 192.168.1.14 and ip.addr eq 192.168.1.13) and (udp.port e...

```
    00000154  d0 16 fe ff 00 00 00 00  00 00 00 00 00 86 01 00 ........ ........
    00000164  00 7a 00 00 00 00 00 00  00 7a fe ff 53 84 24 71 .z...... .z..S.$q
    00000174  b5 0c 5e 43 00 2c e9 25  21 e6 1c 2d 52 4c fe 28 ..^C.,.% !..-RL.(
    00000184  81 59 38 04 58 68 56 44  0e 1e 44 1d 00 00 00 3e .Y8.XhVD ..D....>
    00000194  00 ff c0 24 c0 23 c0 0a  c0 09 c0 08 c0 28 c0 27 ...$.#.. .....(.'
    000001A4  c0 14 c0 13 c0 12 c0 26  c0 25 c0 2a c0 29 c0 05 .......& .%.*.)..
    000001B4  c0 04 c0 03 c0 0f c0 0e  c0 0d 00 3d 00 3c 00 2f ........ ...=.<./
    000001C4  00 35 00 0a 00 67 00 6b  00 33 00 39 00 16 01 00 .5...g.k .3.9....
    000001D4  00 12 00 0a 00 08 00 06  00 17 00 18 00 19 00 0b ........ ........
    000001E4  00 02 01 00                                      ....
000001F8  d0 16 fe ff 00 00 00 00  00 00 00 00 00 52 02 00 ........ .....R..
00000208  00 46 00 00 00 00 00 00  00 46 fe ff 53 84 24 71 .F...... .F..S.$q
00000218  6a ee 06 ec 4b 73 3d 21  38 ef be a6 28 ee 75 98 j...Ks=! 8...(.u.
```

openssl s_client -dtls1 -connect someserver:443



Follow UDP Stream ((ip.addr eq 127.0.0.1 and ip.addr eq 127.0.0.1) and (udp.port eq 49857...

```
0000006F  16 fe ff 00 00 00 00 00  00 00 01 00 76 01 00 00 ........ ....v...
0000007F  6a 00 01 00 00 00 00 00  6a fe ff 53 b9 a1 1a a2 j....... j..S....
0000008F  81 82 ac 40 d1 fa db 74  f7 a3 03 71 46 e2 c9 83 ...@...t ...qF...
0000009F  38 46 4b 7c 4e 98 f8 60  03 f1 3f 00 14 ef f0 65 8FK|N..` ..?....e
000000AF  a1 7f e7 9f cb c1 4d 0f  b8 06 e5 2f 00 85 98 7c ......M. .../...|
000000BF  4c 00 28 00 39 00 38 00  35 00 16 00 13 00 0a 00 L.(.9.8. 5.......
000000CF  33 00 32 00 2f 00 9a 00  99 00 96 00 15 00 12 00 3.2./... ........
000000DF  09 00 14 00 11 00 08 00  06 00 ff 01 00 00 04 00 ........ ........
000000EF  23 00 00                                         #..
    00000030  16 fe ff 00 00 00 00 00  00 00 01 00 3d 02 00 00 ........ ....=...
    00000040  31 00 01 00 00 00 00 00  31 fe ff 53 b9 a1 1a a3 1....... 1..S....
    00000050  6f 9d 49 e3 b5 7d cf 91  06 37 37 10 4b 79 15 80 o.I..}.. .77.Ky..
```

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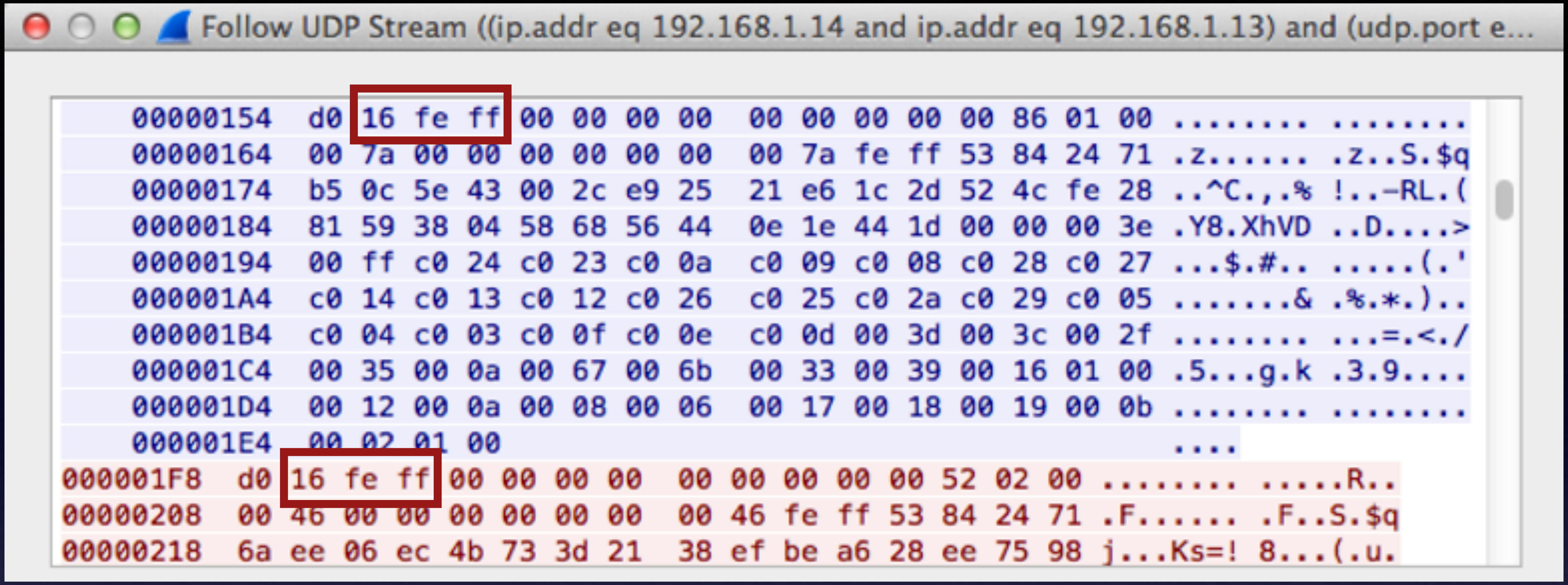

Follow UDP Stream ((ip.addr eq 192.168.1.14 and ip.addr eq 192.168.1.13) and (udp.port e...

```
    00000154  d0 16 fe ff 00 00 00 00  00 00 00 00 00 86 01 00 ........ ........
    00000164  00 7a 00 00 00 00 00 00  00 7a fe ff 53 84 24 71 .z...... .z..S.$q
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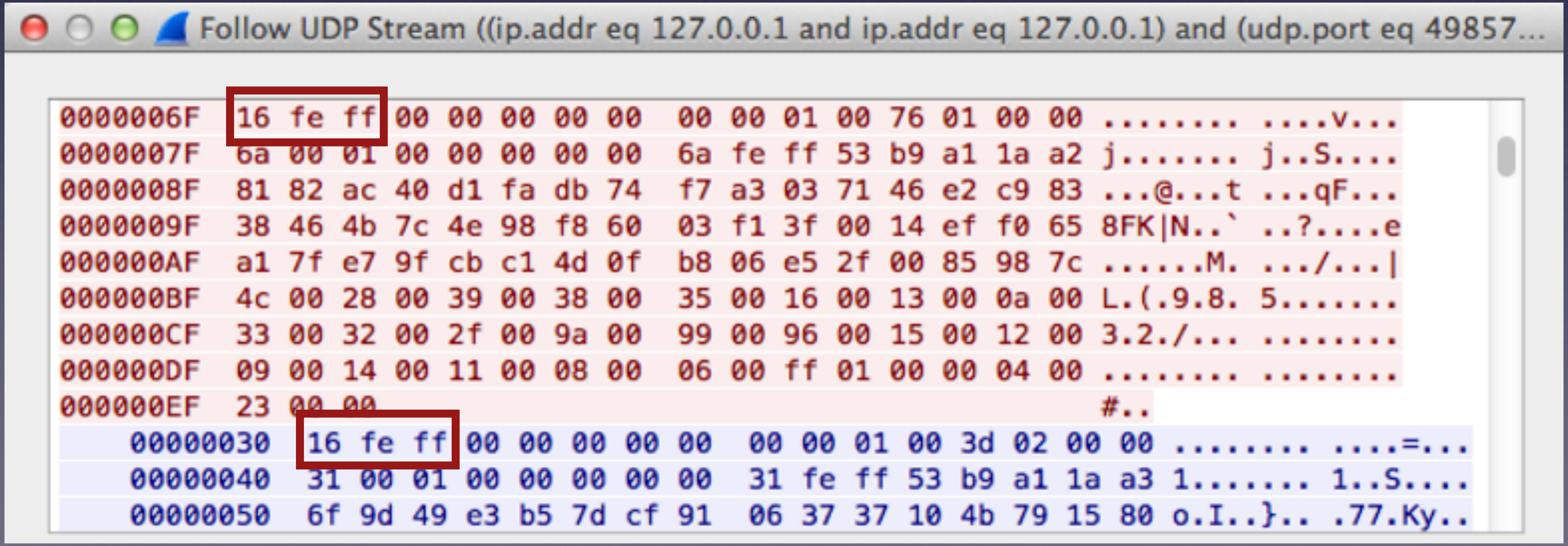
    000001A4  c0 14 c0 13 c0 12 c0 26  c0 25 c0 2a c0 29 c0 05 .......& .%.*.)..
    000001B4  c0 04 c0 03 c0 0f c0 0e  c0 0d 00 3d 00 3c 00 2f ........ ...=.<./
    000001C4  00 35 00 0a 00 67 00 6b  00 33 00 39 00 16 01 00 .5...g.k .3.9....
    000001D4  00 12 00 0a 00 08 00 06  00 17 00 18 00 19 00 0b ........ ........
    000001E4  00 02 01 00                                      ....
000001F8  d0 16 fe ff 00 00 00 00  00 00 00 00 00 52 02 00 ........ .....R..
00000208  00 46 00 00 00 00 00 00  00 46 fe ff 53 84 24 71 .F...... .F..S.$q
00000218  6a ee 06 ec 4b 73 3d 21  38 ef be a6 28 ee 75 98 j...Ks=! 8...(.u.
```

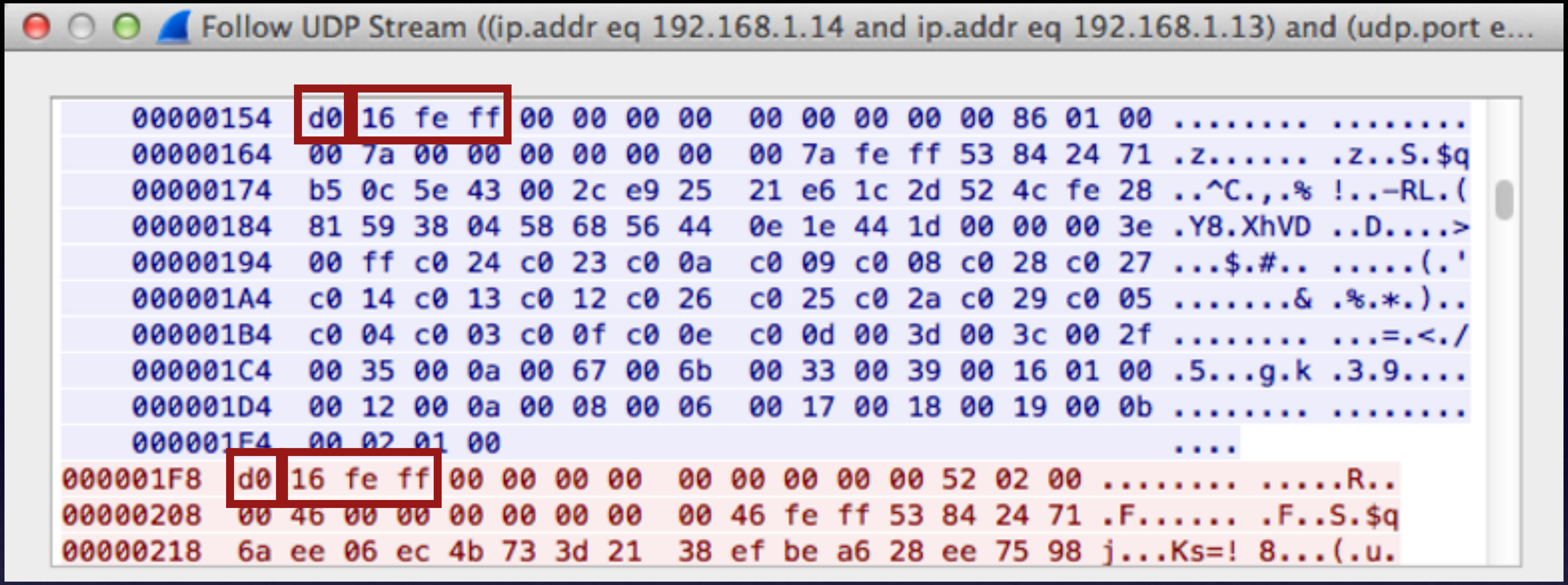
openssl s_client -dtls1 -connect someserver:443



Follow UDP Stream ((ip.addr eq 127.0.0.1 and ip.addr eq 127.0.0.1) and (udp.port eq 49857...

```
0000006F  16 fe ff 00 00 00 00 00  00 00 01 00 76 01 00 00 ........ ....v...
0000007F  6a 00 01 00 00 00 00 00  6a fe ff 53 b9 a1 1a a2 j....... j..S....
0000008F  81 82 ac 40 d1 fa db 74  f7 a3 03 71 46 e2 c9 83 ...@...t ...qF...
0000009F  38 46 4b 7c 4e 98 f8 60  03 f1 3f 00 14 ef f0 65 8FK|N..` ..?....e
000000AF  a1 7f e7 9f cb c1 4d 0f  b8 06 e5 2f 00 85 98 7c ......M. .../...|
000000BF  4c 00 28 00 39 00 38 00  35 00 16 00 13 00 0a 00 L.(.9.8. 5.......
000000CF  33 00 32 00 2f 00 9a 00  99 00 96 00 15 00 12 00 3.2./... ........
000000DF  09 00 14 00 11 00 08 00  06 00 ff 01 00 00 04 00 ........ ........
000000EF  23 00 00                                         #..
    00000030  16 fe ff 00 00 00 00 00  00 00 01 00 3d 02 00 00 ........ ....=...
    00000040  31 00 01 00 00 00 00 00  31 fe ff 53 b9 a1 1a a3 1....... 1..S....
    00000050  6f 9d 49 e3 b5 7d cf 91  06 37 37 10 4b 79 15 80 o.I..}.. .77.Ky..
```

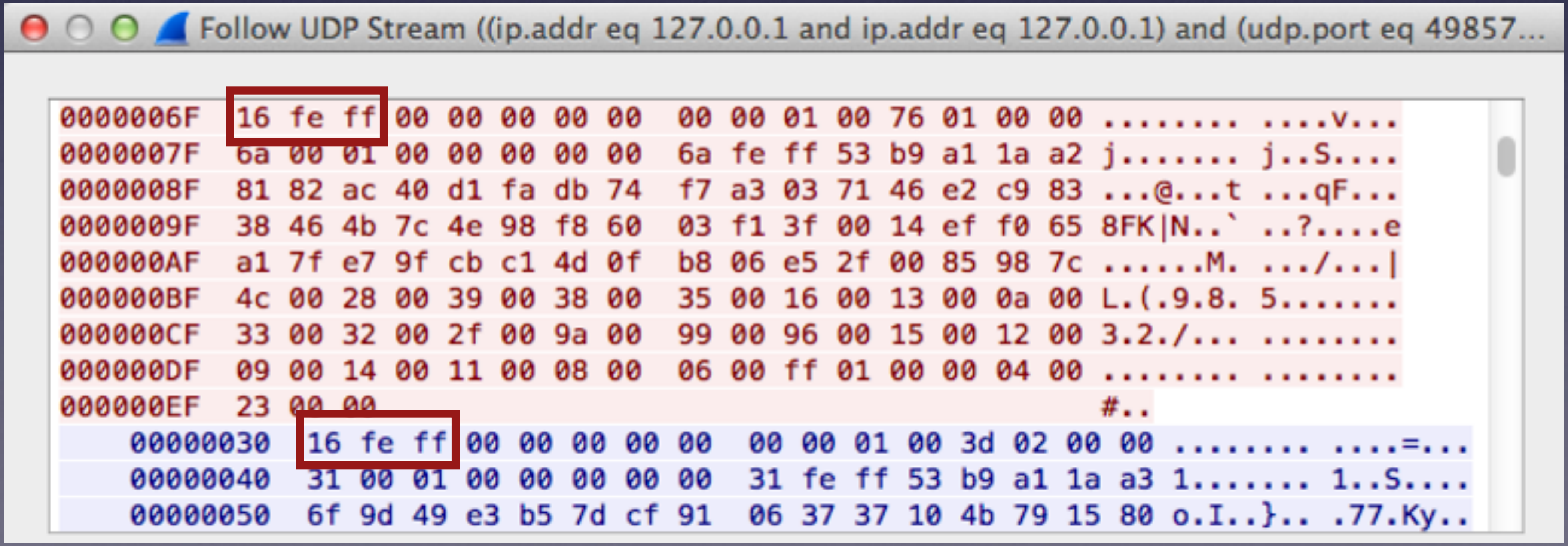
Mystery Protocol #2



Follow UDP Stream ((ip.addr eq 192.168.1.14 and ip.addr eq 192.168.1.13) and (udp.port e...

```
00000154  d0 16 fe ff 00 00 00 00  00 00 00 00 00 86 01 00 ........ ........
00000164  00 7a 00 00 00 00 00 00  00 7a fe ff 53 84 24 71 .z...... .z..S.$q
00000174  b5 0c 5e 43 00 2c e9 25  21 e6 1c 2d 52 4c fe 28 ..^C.,.% !..-RL.(
00000184  81 59 38 04 58 68 56 44  0e 1e 44 1d 00 00 00 3e .Y8.XhVD ..D....>
00000194  00 ff c0 24 c0 23 c0 0a  c0 09 c0 08 c0 28 c0 27 ...$.#.. .....(.'
000001A4  c0 14 c0 13 c0 12 c0 26  c0 25 c0 2a c0 29 c0 05 .......& .%.*.)..
000001B4  c0 04 c0 03 c0 0f c0 0e  c0 0d 00 3d 00 3c 00 2f ........ ...=.<./
000001C4  00 35 00 0a 00 67 00 6b  00 33 00 39 00 16 01 00 .5...g.k .3.9....
000001D4  00 12 00 0a 00 08 00 06  00 17 00 18 00 19 00 0b ........ ........
000001E4  00 02 01 00                                      ....
000001F8  d0 16 fe ff 00 00 00 00  00 00 00 00 00 52 02 00 ........ .....R..
00000208  00 46 00 00 00 00 00 00  00 46 fe ff 53 84 24 71 .F...... .F..S.$q
00000218  6a ee 06 ec 4b 73 3d 21  38 ef be a6 28 ee 75 98 j...Ks=! 8...(.u.
```

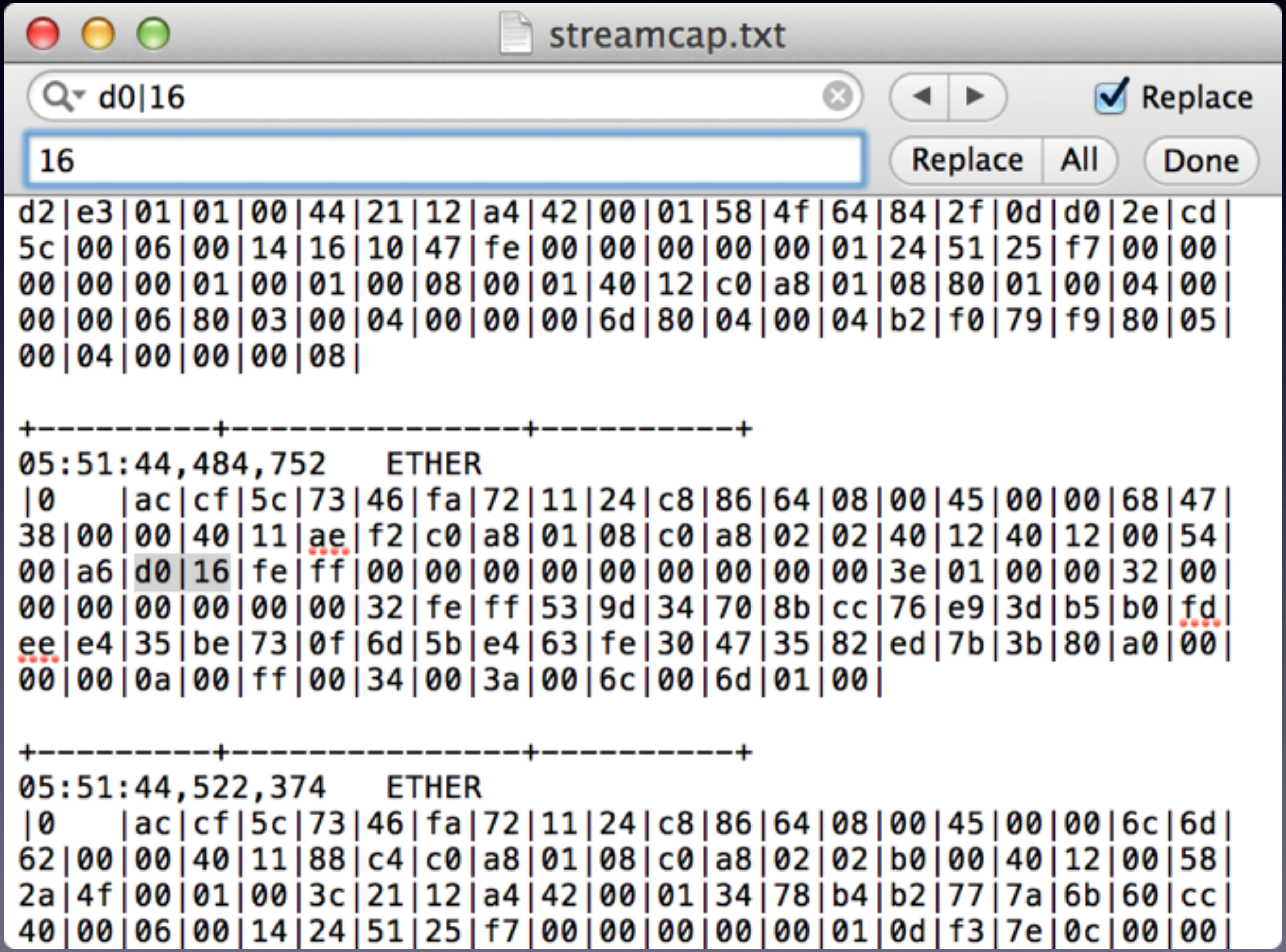
openssl s_client -dtls1 -connect someserver:443



Follow UDP Stream ((ip.addr eq 127.0.0.1 and ip.addr eq 127.0.0.1) and (udp.port eq 49857...

```
0000006F  16 fe ff 00 00 00 00 00  00 00 01 00 76 01 00 00 ........ ....v...
0000007F  6a 00 01 00 00 00 00 00  6a fe ff 53 b9 a1 1a a2 j....... j..S....
0000008F  81 82 ac 40 d1 fa db 74  f7 a3 03 71 46 e2 c9 83 ...@...t ...qF...
0000009F  38 46 4b 7c 4e 98 f8 60  03 f1 3f 00 14 ef f0 65 8FK|N..` ..?....e
000000AF  a1 7f e7 9f cb c1 4d 0f  b8 06 e5 2f 00 85 98 7c ......M. .../...|
000000BF  4c 00 28 00 39 00 38 00  35 00 16 00 13 00 0a 00 L.(.9.8. 5.......
000000CF  33 00 32 00 2f 00 9a 00  99 00 96 00 15 00 12 00 3.2./... ........
000000DF  09 00 14 00 11 00 08 00  06 00 ff 01 00 00 04 00 ........ ........
000000EF  23 00 00                                         #..
00000030  16 fe ff 00 00 00 00 00  00 00 01 00 3d 02 00 00 ........ ....=...
00000040  31 00 01 00 00 00 00 00  31 fe ff 53 b9 a1 1a a3 1....... 1..S....
00000050  6f 9d 49 e3 b5 7d cf 91  06 37 37 10 4b 79 15 80 o.I..}.. .77.Ky..
```

Pro Packet Trace Editing



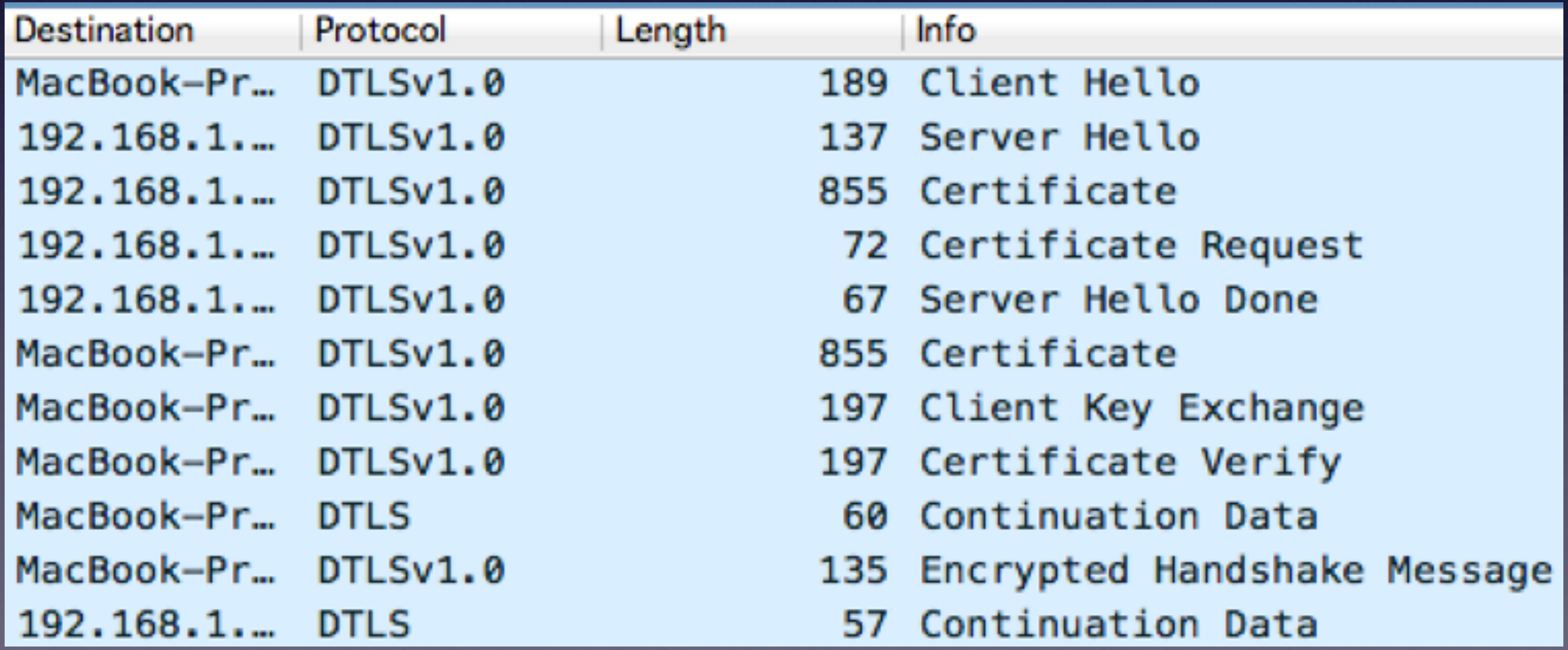
```
d2|e3|01|01|00|44|21|12|a4|42|00|01|58|4f|64|84|2f|0d|d0|2e|cd|
5c|00|06|00|14|16|10|47|fe|00|00|00|00|00|01|24|51|25|f7|00|00|
00|00|00|01|00|01|00|08|00|01|40|12|c0|a8|01|08|80|01|00|04|00|
00|00|06|80|03|00|04|00|00|00|6d|80|04|00|04|b2|f0|79|f9|80|05|
00|04|00|00|00|08|

+---------+---------------+----------+
05:51:44,484,752   ETHER
|0   |ac|cf|5c|73|46|fa|72|11|24|c8|86|64|08|00|45|00|00|68|47|
38|00|00|40|11|ae|f2|c0|a8|01|08|c0|a8|02|02|40|12|40|12|00|54|
00|a6|d0|16|fe|ff|00|00|00|00|00|00|00|00|00|3e|01|00|00|32|00|
00|00|00|00|00|00|32|fe|ff|53|9d|34|70|8b|cc|76|e9|3d|b5|b0|fd|
ee|e4|35|be|73|0f|6d|5b|e4|63|fe|30|47|35|82|ed|7b|3b|80|a0|00|
00|00|0a|00|ff|00|34|00|3a|00|6c|00|6d|01|00|

+---------+---------------+----------+
05:51:44,522,374   ETHER
|0   |ac|cf|5c|73|46|fa|72|11|24|c8|86|64|08|00|45|00|00|6c|6d|
62|00|00|40|11|88|c4|c0|a8|01|08|c0|a8|02|02|b0|00|40|12|00|58|
2a|4f|00|01|00|3c|21|12|a4|42|00|01|34|78|b4|b2|77|7a|6b|60|cc|
40|00|06|00|14|24|51|25|f7|00|00|00|00|00|01|0d|f3|7e|0c|00|00|
```

Pro Packet Trace Editing

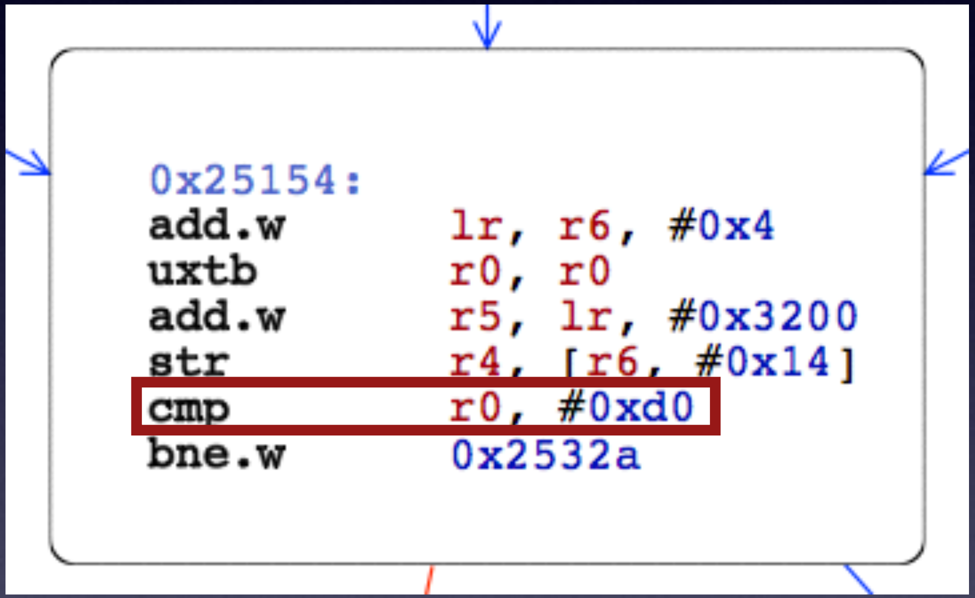
- Success!



Destination	Protocol	Length	Info
MacBook-Pr…	DTLSv1.0	189	Client Hello
192.168.1.…	DTLSv1.0	137	Server Hello
192.168.1.…	DTLSv1.0	855	Certificate
192.168.1.…	DTLSv1.0	72	Certificate Request
192.168.1.…	DTLSv1.0	67	Server Hello Done
MacBook-Pr…	DTLSv1.0	855	Certificate
MacBook-Pr…	DTLSv1.0	197	Client Key Exchange
MacBook-Pr…	DTLSv1.0	197	Certificate Verify
MacBook-Pr…	DTLS	60	Continuation Data
MacBook-Pr…	DTLSv1.0	135	Encrypted Handshake Message
192.168.1.…	DTLS	57	Continuation Data

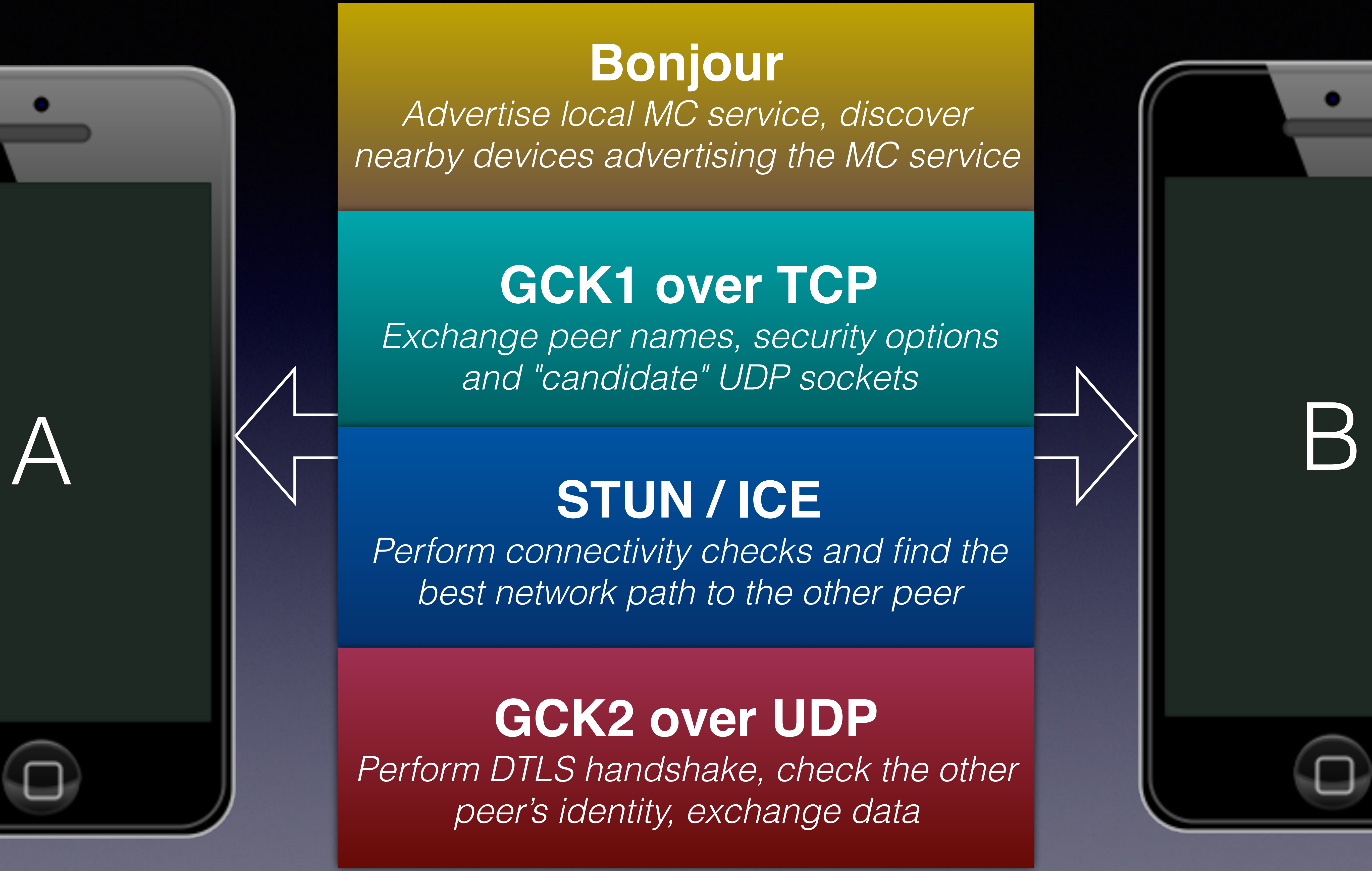
Mystery Protocol #2

- DTLS 1.0 with the byte 0xd0 appended to **every** DTLS record
- *_gckSessionRecvMessage()*



```
0x25154:
add.w       lr, r6, #0x4
uxtb        r0, r0
add.w       r5, lr, #0x3200
str         r4, [r6, #0x14]
cmp         r0, #0xd0
bne.w       0x2532a
```

- Inside the DTLS stream:
  - Simple plaintext protocol
  - The other peer’s PeerID + App data/messages



Bonjour

Advertise local MC service, discover nearby devices advertising the MC service

GCK1 over TCP

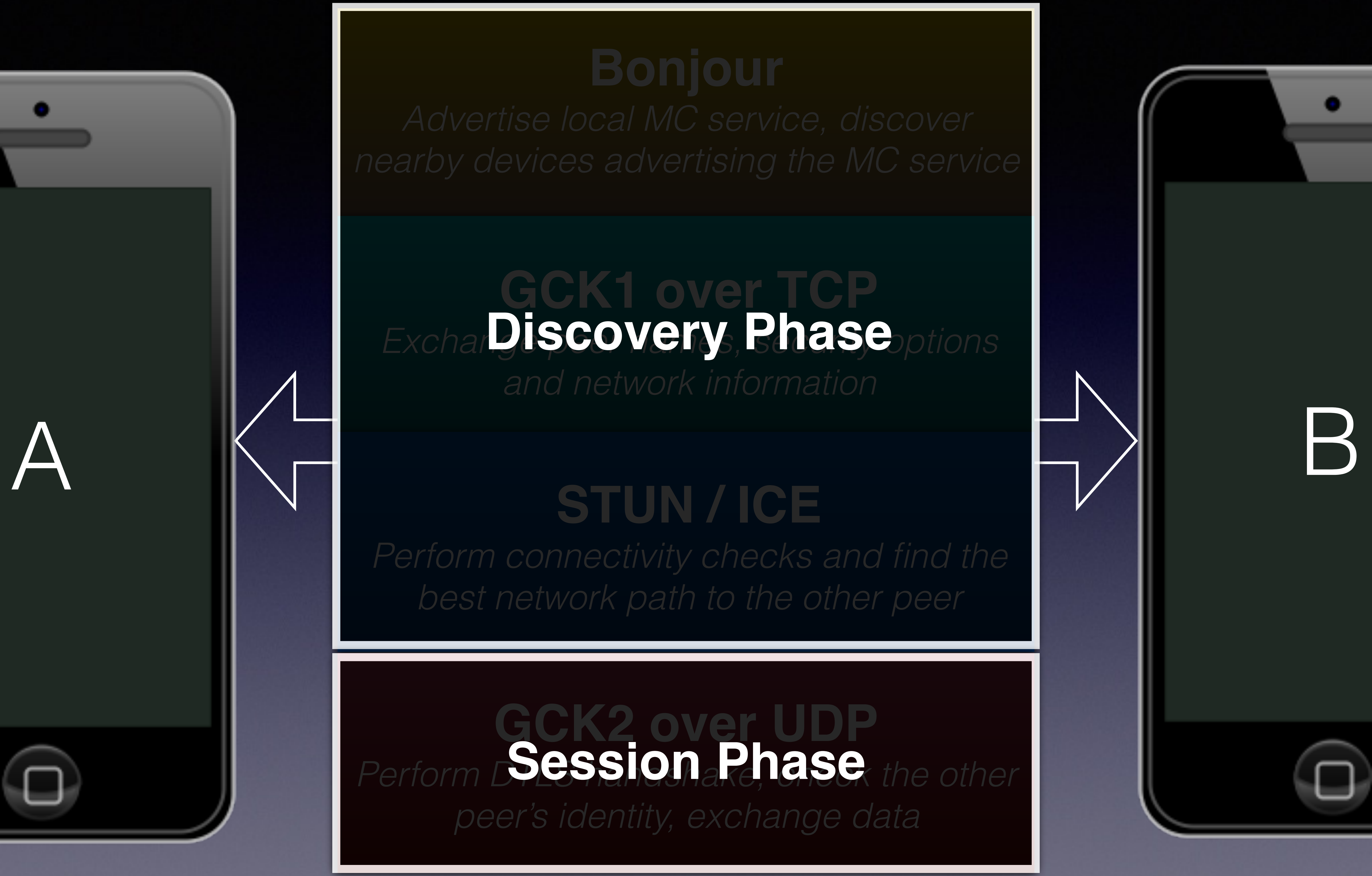
Exchange peer names, security options and "candidate" UDP sockets

STUN / ICE

Perform connectivity checks and find the best network path to the other peer

GCK2 over UDP

Perform DTLS handshake, check the other peer's identity, exchange data



Bonjour

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GCK1 over TCP

Exchange peer names, security options and network information

STUN / ICE

Perform connectivity checks and find the best network path to the other peer

GCK2 over UDP

Perform DTLS handshake, check the other peer's identity, exchange data

Security Analysis of Multipeer Connectivity

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication			
With Authentication			

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication			
With Authentication			

MC Security Analysis

- **MCEncryptionRequired With Authentication:** DTLS with **mutual** authentication
    - Each peer sends their certificate and validate the other side's certificate
    - RSA & EC-DSA TLS Cipher Suites
        - 30 cipher suites supported in total including PFS cipher suites.
        - In practice, **TLS_RSA_WITH_AES_256_CBC_SHA256** is always negotiated, which doesn't provide PFS

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication			
With Authentication			No PFS

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication			
With Authentication			No PFS

MC Security Analysis

- **MCEncryptionRequired Without Authentication:** DTLS with Anonymous TLS Cipher Suites
  - No certificates exchanged
  - “Anon" AES TLS cipher suites:
    - TLS_DH_anon_WITH_AES_128_CBC_SHA, TLS_DH_anon_WITH_AES_256_CBC_SHA, TLS_DH_anon_WITH_AES_128_CBC_SHA256, TLS_DH_anon_WITH_AES_256_CBC_SHA256

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication			MiTM
With Authentication			No PFS

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication			MiTM
With Authentication			No PFS

MC Security Analysis

- **MCEncryptionNone Without Authentication:** No DTLS - Plaintext GCK2 protocol

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication	Plaintext		MiTM
With Authentication			No PFS

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication	Plaintext		MiTM
With Authentication			No PFS

MC Security Analysis

- **MCEncryptionNone With Authentication:** DTLS with **mutual** authentication
  - Each peer send their certificate and validate the other side's certificate
  - Plaintext / “No Encryption” TLS Cipher Suites!
    - TLS_RSA_WITH_NULL_SHA , TLS_RSA_WITH_NULL_SHA256

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication	Plaintext		MiTM
With Authentication	Plaintext		No PFS

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication	Plaintext		MiTM
With Authentication	Plaintext		No PFS

MC Security Analysis

- **MCEncryptionOptional Without Authentication**
- ”The session **prefers** to use encryption, but will accept unencrypted connections”

Conclusion

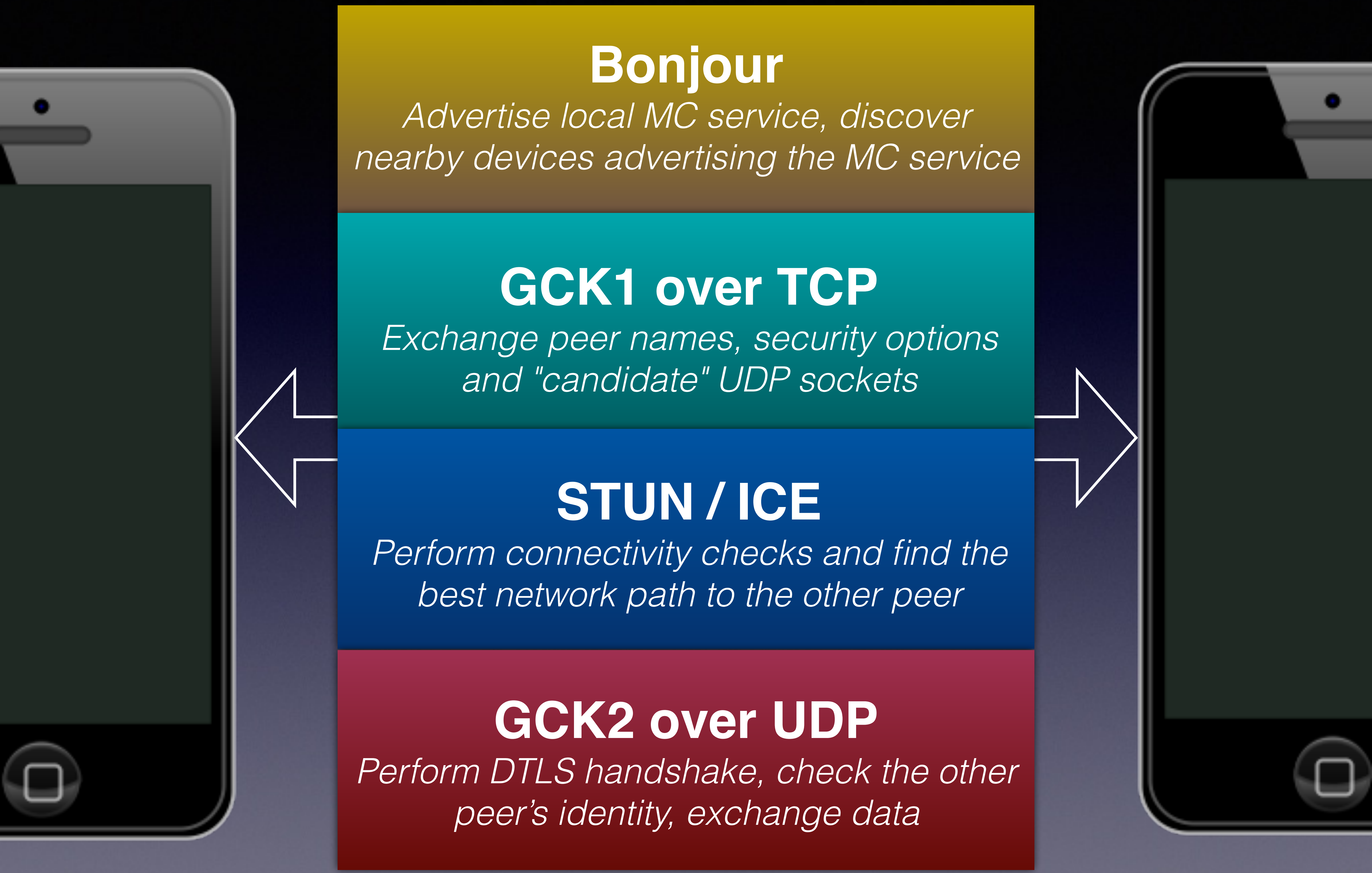
	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication	Plaintext	MitM	MitM
With Authentication	Plaintext		No PFS

Conclusion

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication	Plaintext	MitM	MitM
With Authentication	Plaintext		No PFS

MC Security Analysis

- **MCEncryptionOptional With Authentication**
- ”The session **prefers** to use encryption, but will accept unencrypted connections”
  - Two peers using MCEncryptionOptional with Authentication should get the same security as MCEncryptionRequired
  - Authentication should prevent a man-in-the-middle from tampering with the network traffic



Bonjour

Advertise local MC service, discover nearby devices advertising the MC service

GCK1 over TCP

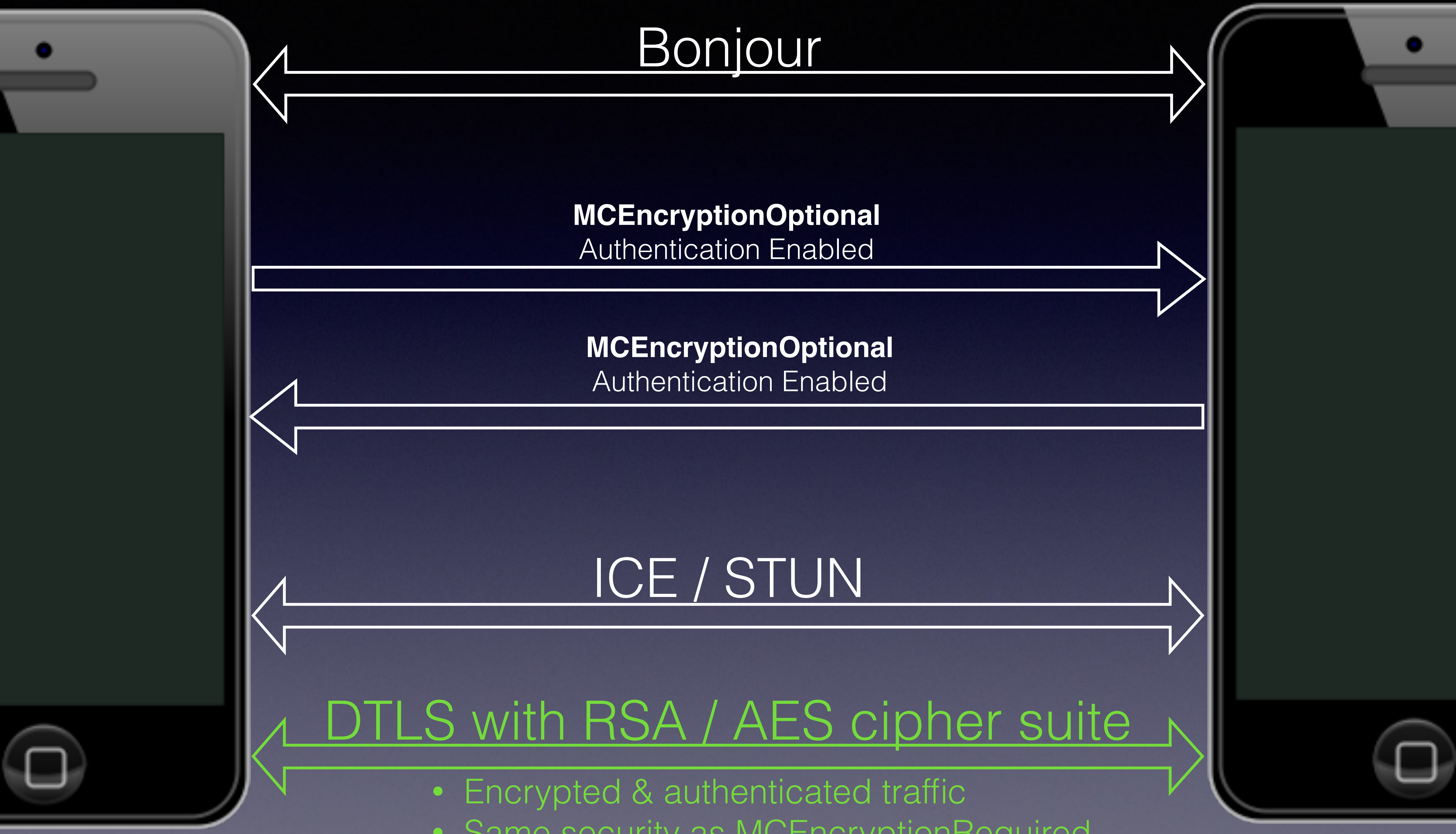
Exchange peer names, security options and "candidate" UDP sockets

STUN / ICE

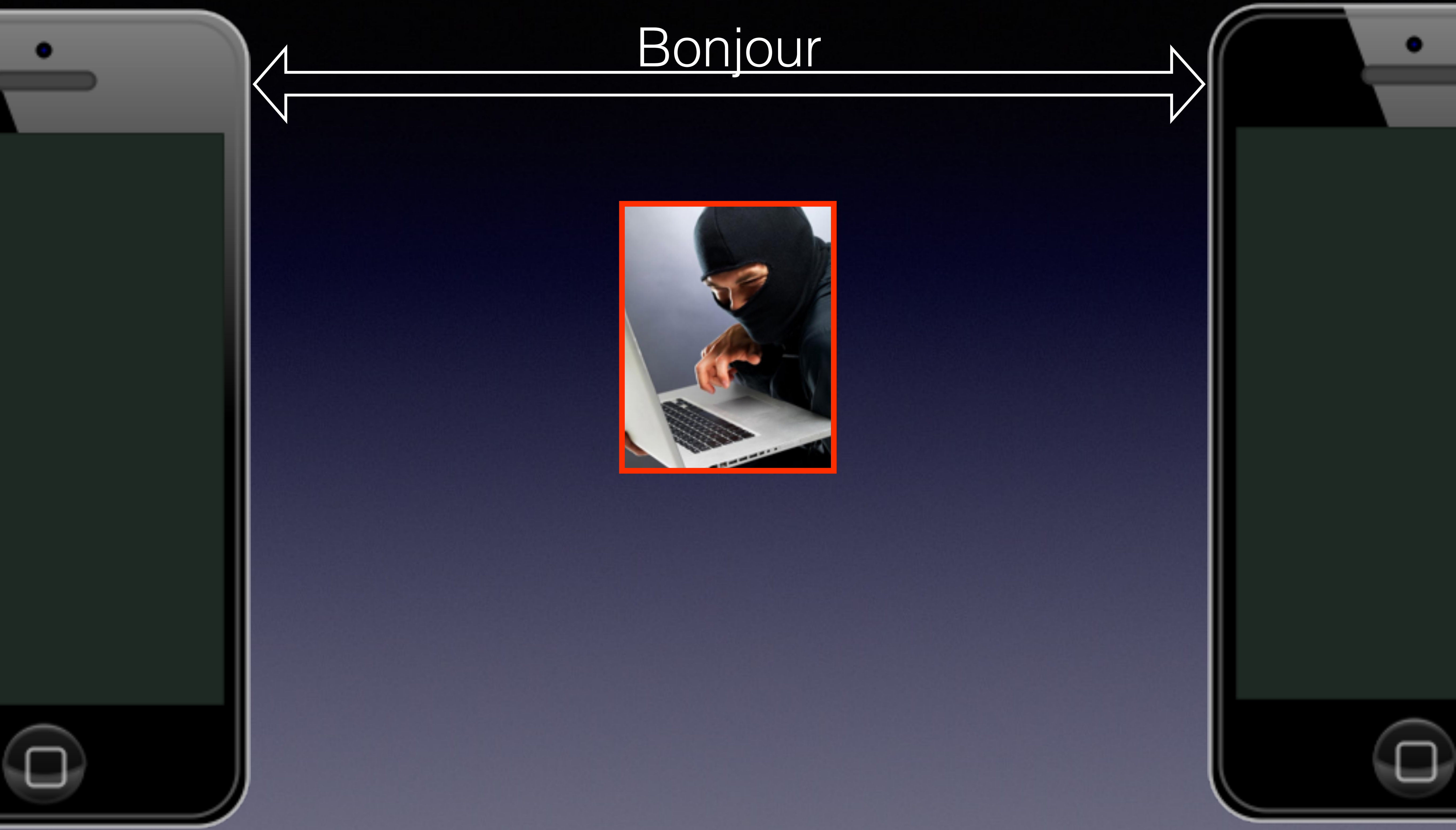
Perform connectivity checks and find the best network path to the other peer

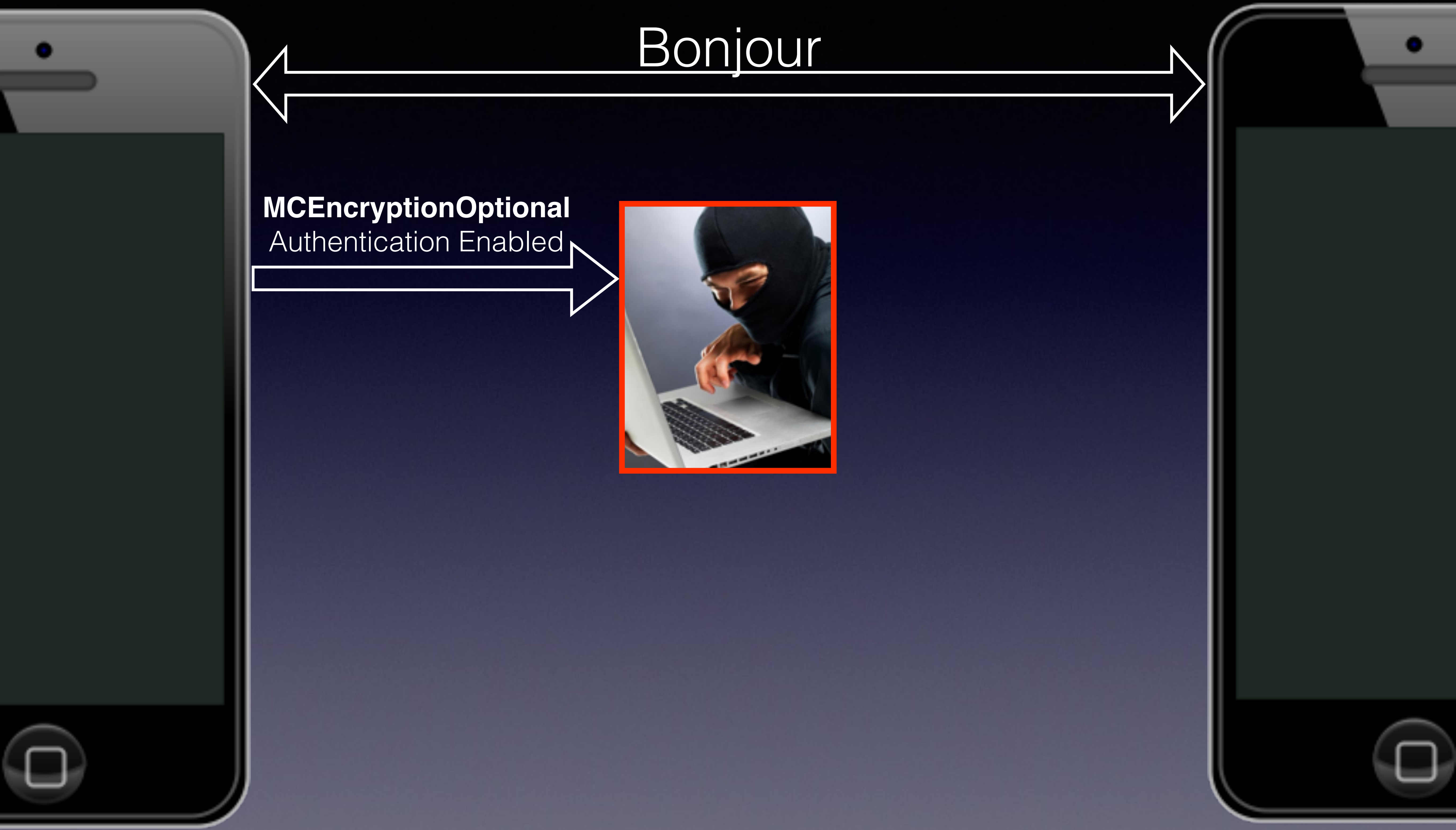
GCK2 over UDP

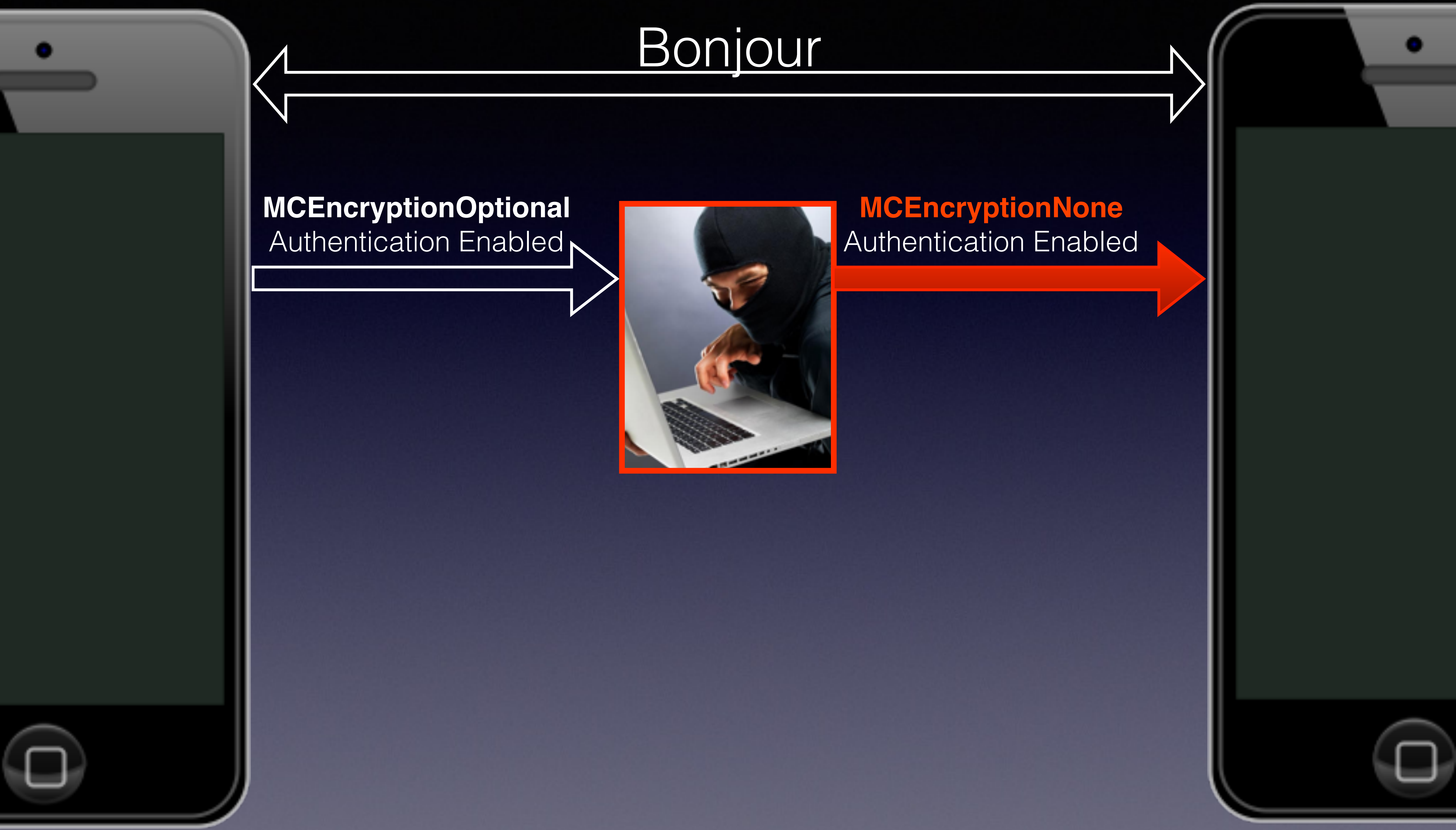
Perform DTLS handshake, check the other peer's identity, exchange data

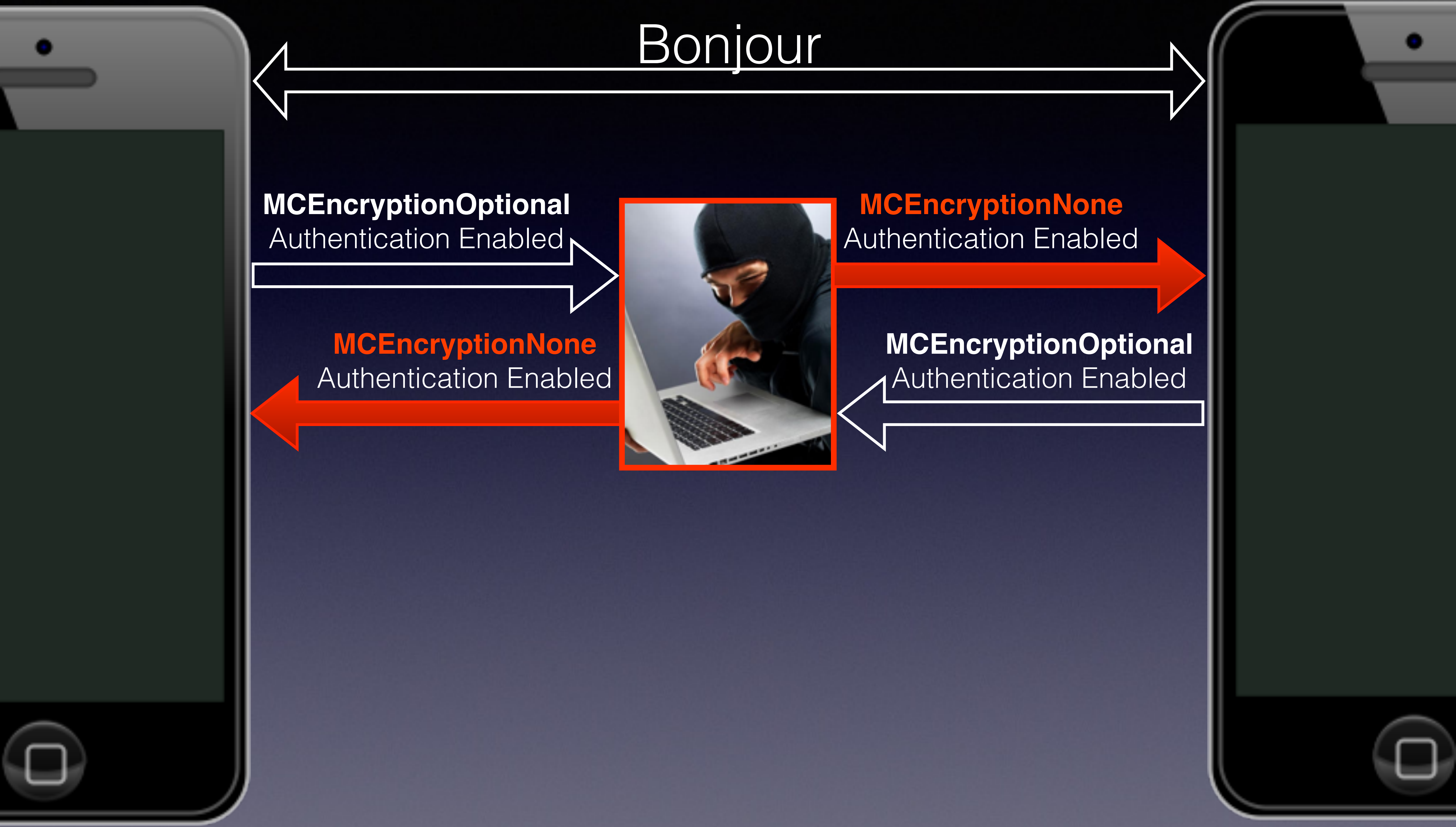


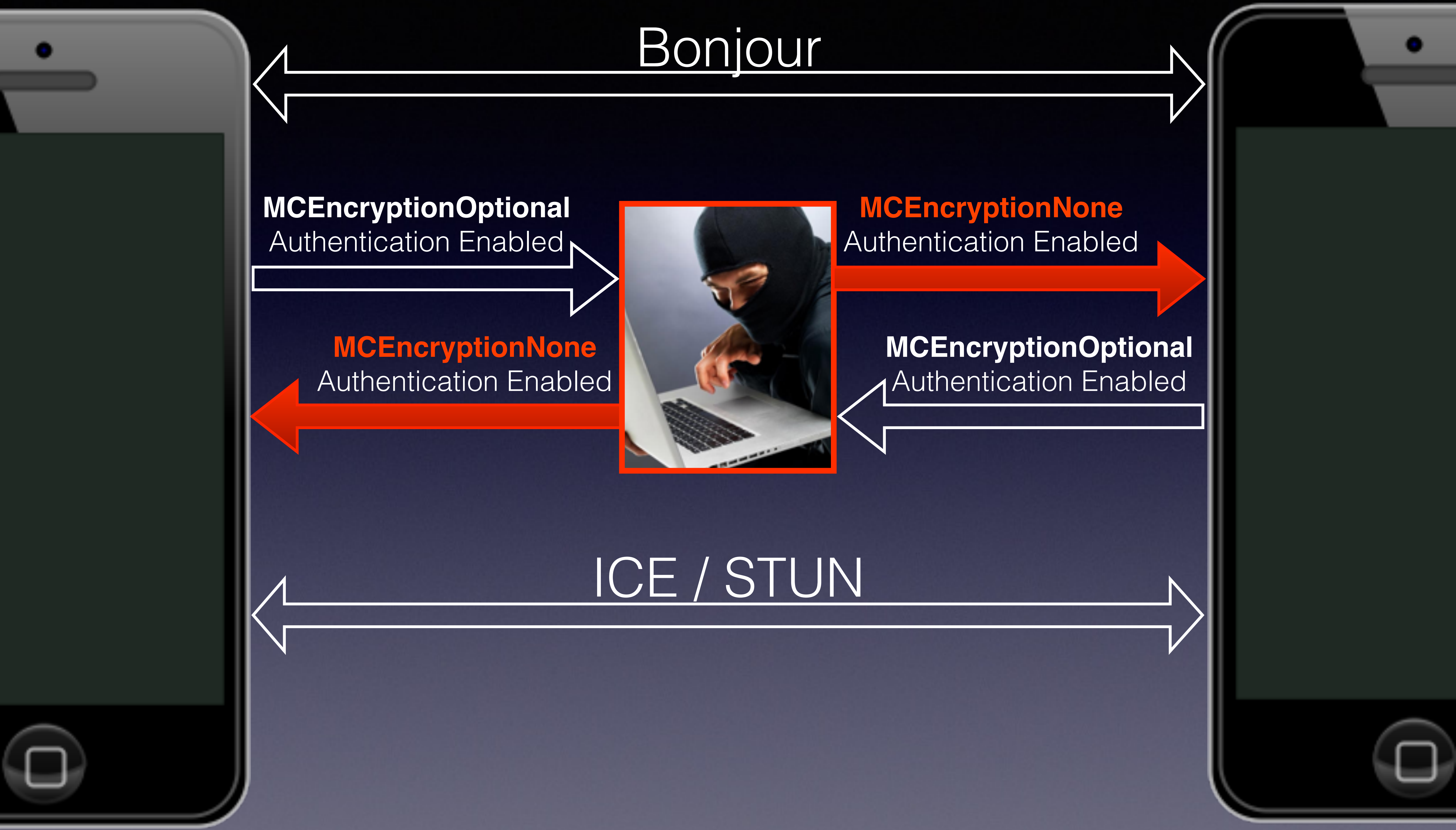
- Encrypted & authenticated traffic
- Same security as MCEncryptionRequired

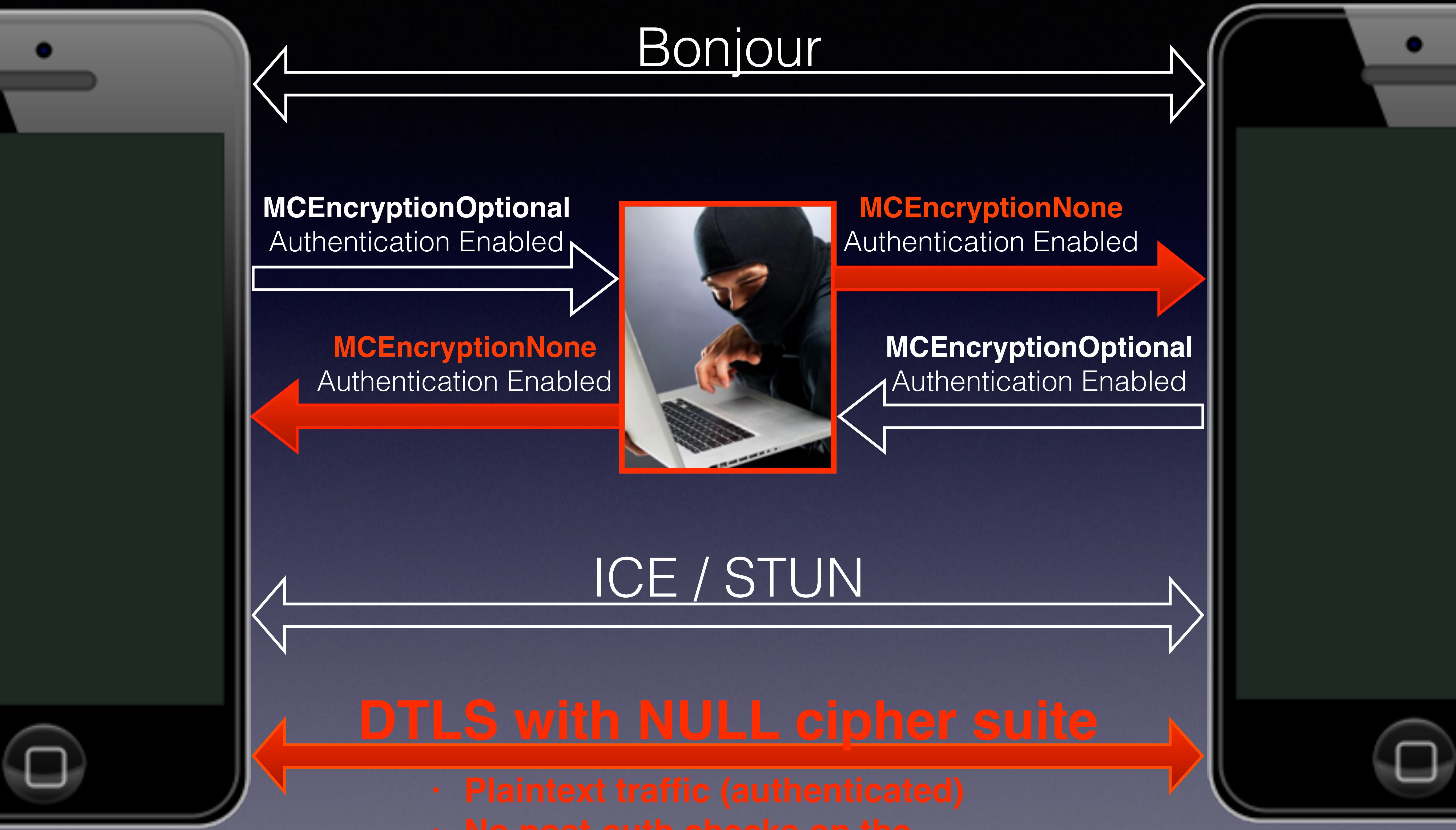

Bonjour


Bonjour
MCEncryptionOptional
Authentication Enabled


Bonjour
MCEncryptionOptional
Authentication Enabled
MCEncryptionNone
Authentication Enabled

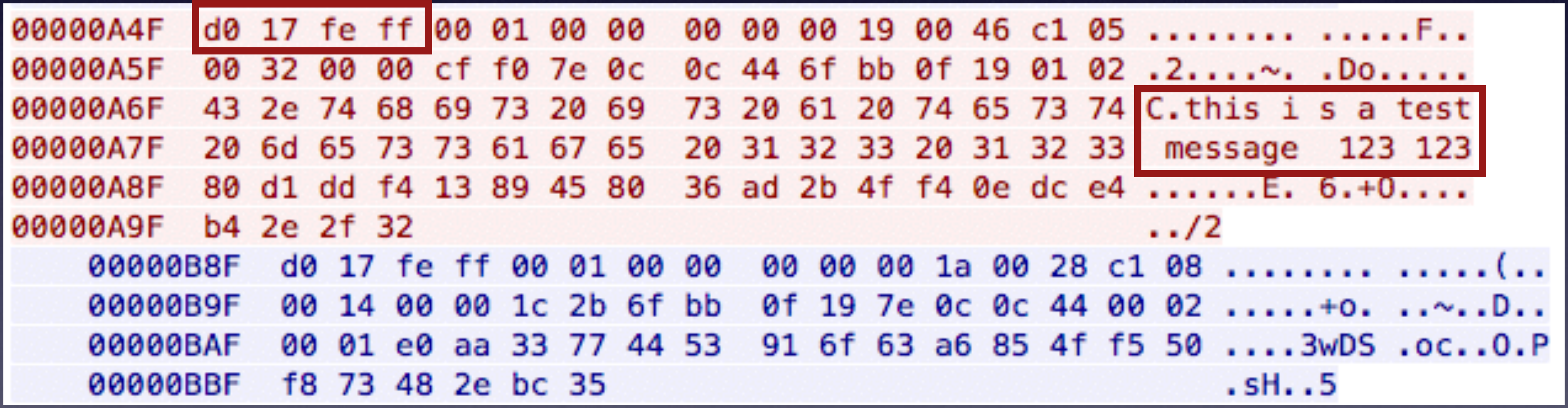

Bonjour
MCEncryptionOptional
Authentication Enabled
MCEncryptionNone
Authentication Enabled
MCEncryptionNone
Authentication Enabled
MCEncryptionOptional
Authentication Enabled


Bonjour
MCEncryptionOptional
Authentication Enabled
MCEncryptionNone
Authentication Enabled
MCEncryptionNone
Authentication Enabled
MCEncryptionOptional
Authentication Enabled
ICE / STUN



- Plaintext traffic (authenticated)
- No post-auth checks on the MCEncryption parameters exchanged
- Same security as MCEncryptionNone

MCEncryptionOptional Downgrade Attack



```
00000A4F  d0 17 fe ff 00 01 00 00  00 00 00 19 00 46 c1 05 ........ .....F..
00000A5F  00 32 00 00 cf f0 7e 0c  0c 44 6f bb 0f 19 01 02 .2....~. .Do.....
00000A6F  43 2e 74 68 69 73 20 69  73 20 61 20 74 65 73 74 C.this i s a test
00000A7F  20 6d 65 73 73 61 67 65  20 31 32 33 20 31 32 33  message  123 123
00000A8F  80 d1 dd f4 13 89 45 80  36 ad 2b 4f f4 0e dc e4 ......E. 6.+O....
00000A9F  b4 2e 2f 32                                       ../2
    00000B8F  d0 17 fe ff 00 01 00 00  00 00 00 1a 00 28 c1 08 ........ .....(..
    00000B9F  00 14 00 00 1c 2b 6f bb  0f 19 7e 0c 0c 44 00 02 .....+o. ..~..D..
    00000BAF  00 01 e0 aa 33 77 44 53  91 6f 63 a6 85 4f f5 50 ....3wDS .oc..O.P
    00000BBF  f8 73 48 2e bc 35                                .sH..5
```

MC Security Analysis

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication	Plaintext	MitM	MitM
With Authentication	Plaintext	MitM (Downgrade)	No PFS

Conclusion

Conclusion

- Most security settings work as advertised by the MC documentation
  - **Except for** MCEncryptionOptional with Authentication
- Some combinations should never be used
  - MCEncryptionOptional
  - MCEncryptionNone with Authentication
- Only MCEncryptionRequired with Authentication is secure

Conclusion

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication	Plaintext	MitM	MitM
With Authentication	Plaintext	MitM (Downgrade)	No PFS

Conclusion

	MCEncryption None	MCEncryption Optional	MCEncryption Required
Without Authentication	Plaintext	MitM	MitM
With Authentication	Plaintext	MitM (Downgrade)	No PFS

Conclusion

- Possible improvements to the MC Framework:
    - MCEncryptionRequired with Authentication:
        - Prioritize Perfect Forward Secrecy TLS Cipher Suites
    - MCEncryptionOptional with Authentication:
        - Peers should validate security parameters post-authentication to prevent downgrade attacks
        - Better: remove MCEncryptionOptional and make MCEncryptionRequired the default setting?

Thanks!

More at
https://nabla-c0d3.github.io