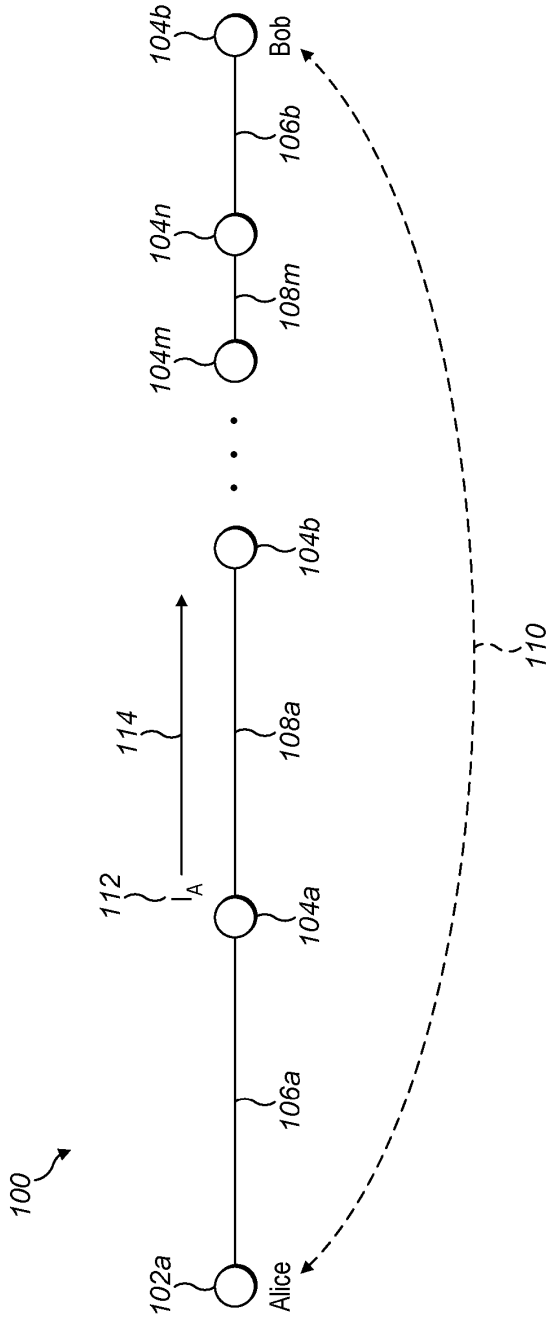

100
102a
Alice
106a
104a
112
I_A
114
108a
104b
104m
108m
104n
106b
104b
Bob
110

FIG. 1A

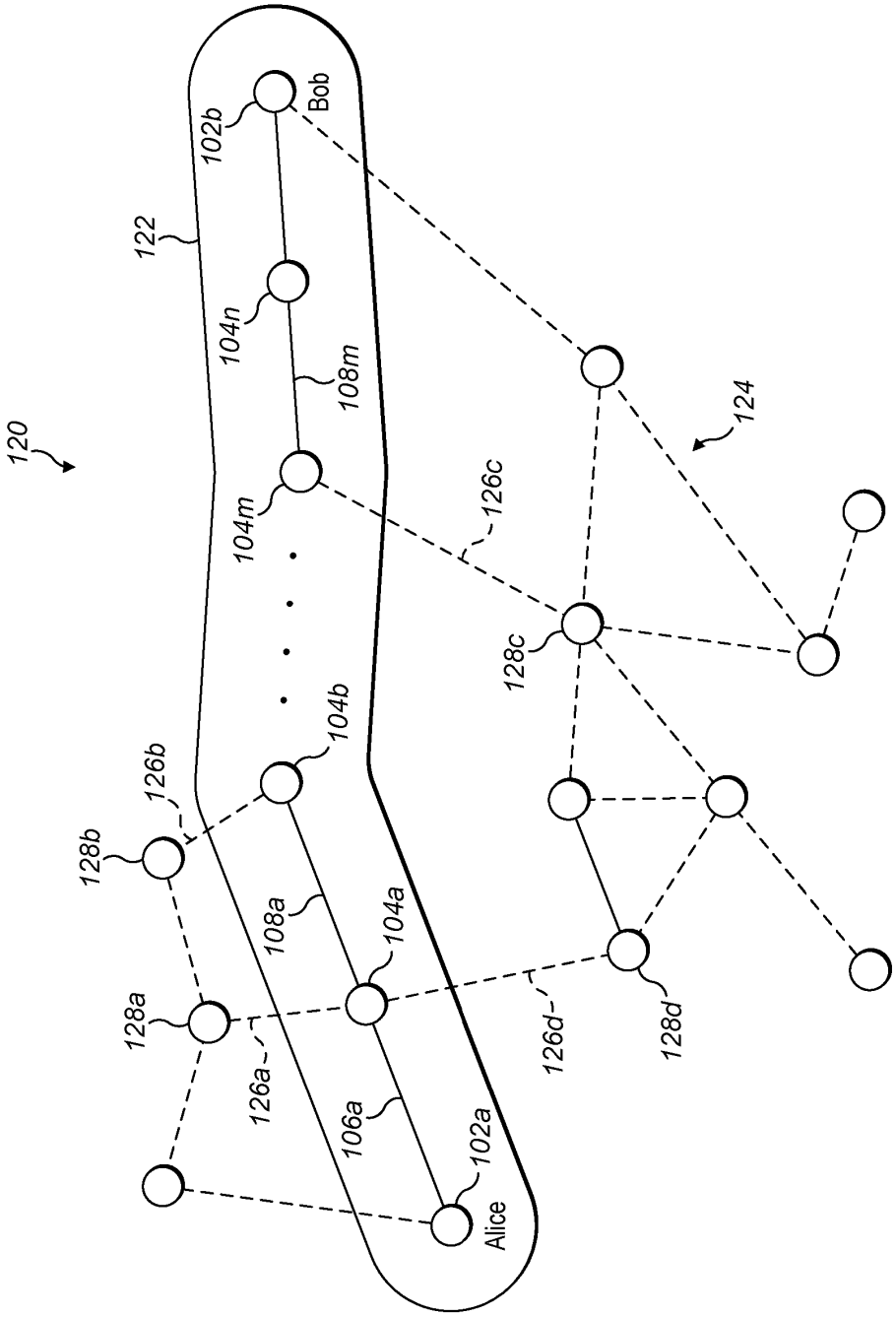

120
122
Bob
102b
104n
108m
104m
126c
124
128c
104b
126b
128b
108a
104a
128a
126a
106a
102a
Alice
126d
128d

FIG. 1B

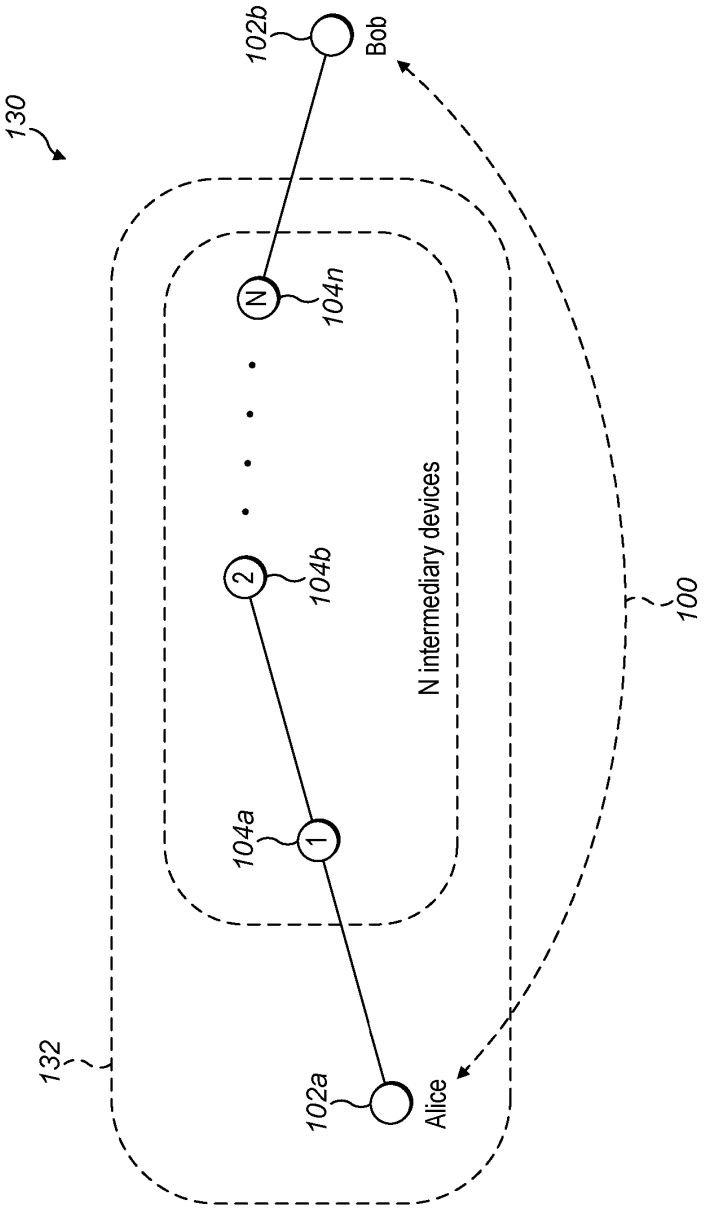

130
102b
Bob
N
104n
2
104b
1
104a
N intermediary devices
100
132
102a
Alice

FIG. 1C

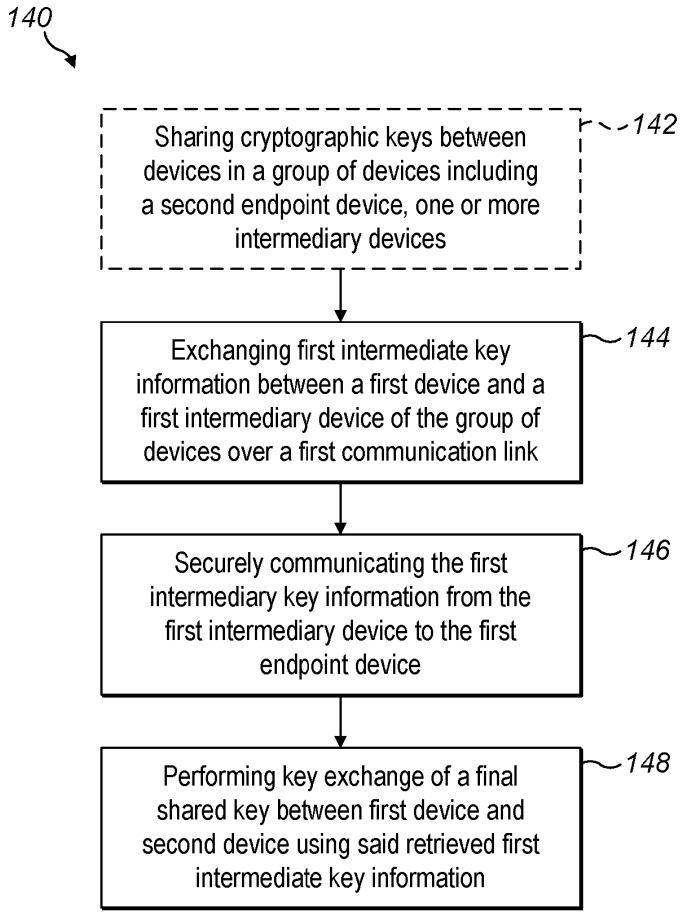

140
Sharing cryptographic keys between devices in a group of devices including a second endpoint device, one or more intermediary devices
142
Exchanging first intermediate key information between a first device and a first intermediary device of the group of devices over a first communication link
144
Securely communicating the first intermediary key information from the first intermediary device to the first endpoint device
146
Performing key exchange of a final shared key between first device and second device using said retrieved first intermediate key information
148

FIG. 1D

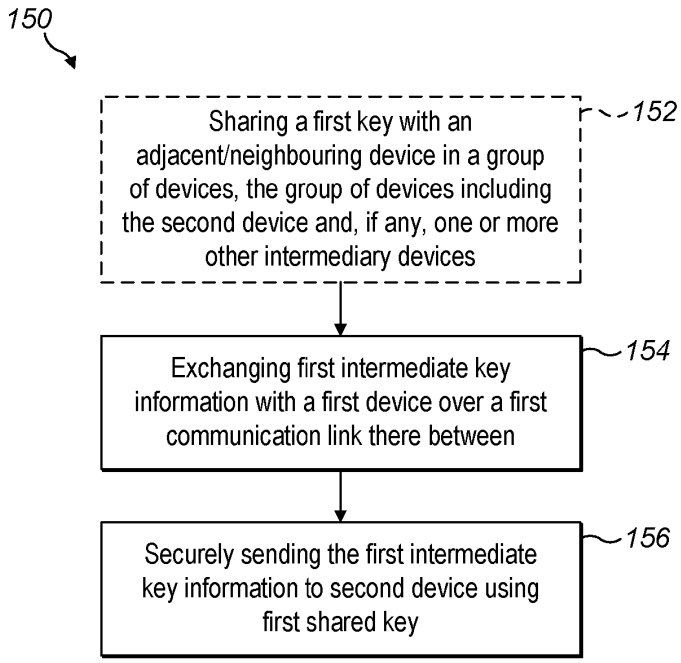

150
Sharing a first key with an adjacent/neighbouring device in a group of devices, the group of devices including the second device and, if any, one or more other intermediary devices
152
Exchanging first intermediate key information with a first device over a first communication link there between
154
Securely sending the first intermediate key information to second device using first shared key
156

FIG. 1E

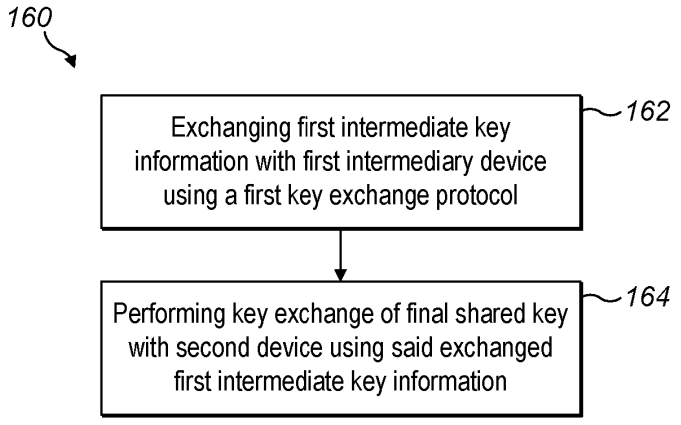

160
Exchanging first intermediate key information with first intermediary device using a first key exchange protocol
162
Performing key exchange of final shared key with second device using said exchanged first intermediate key information
164

FIG. 1F

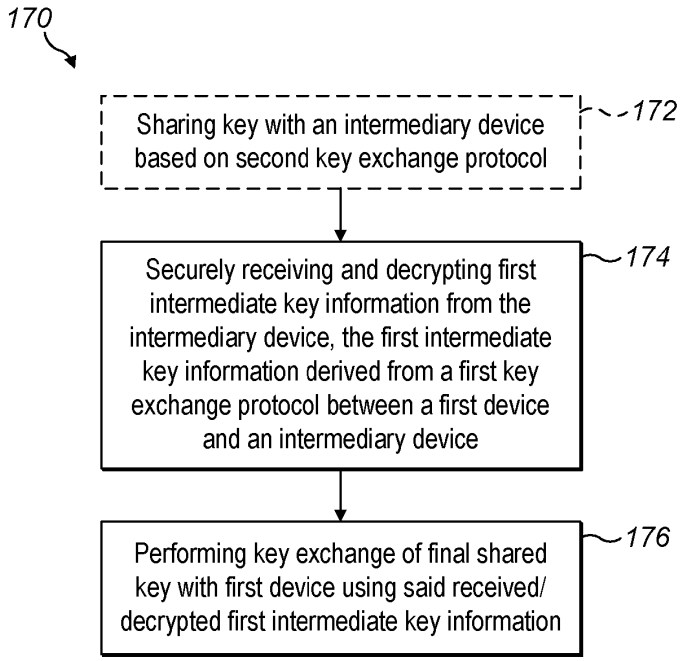

170
Sharing key with an intermediary device based on second key exchange protocol
172
Securely receiving and decrypting first intermediate key information from the intermediary device, the first intermediate key information derived from a first key exchange protocol between a first device and an intermediary device
174
Performing key exchange of final shared key with first device using said received/ decrypted first intermediate key information
176

FIG. 1G

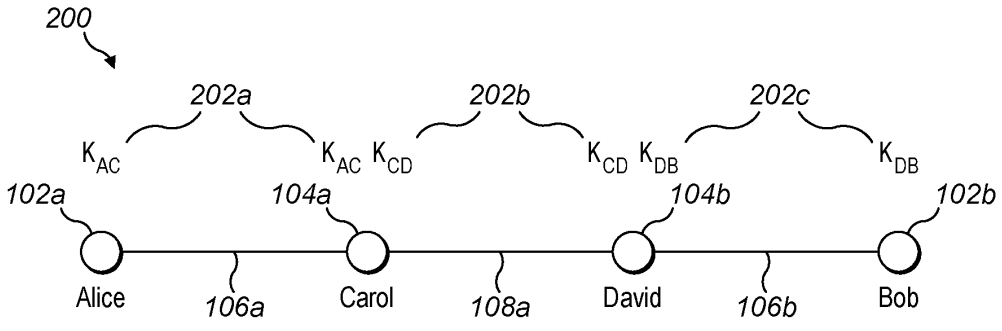

200
202a
202b
202c
K_{AC}
K_{AC} K_{CD}
K_{CD} K_{DB}
K_{DB}
102a
104a
104b
102b
Alice
106a
Carol
108a
David
106b
Bob

FIG. 2A

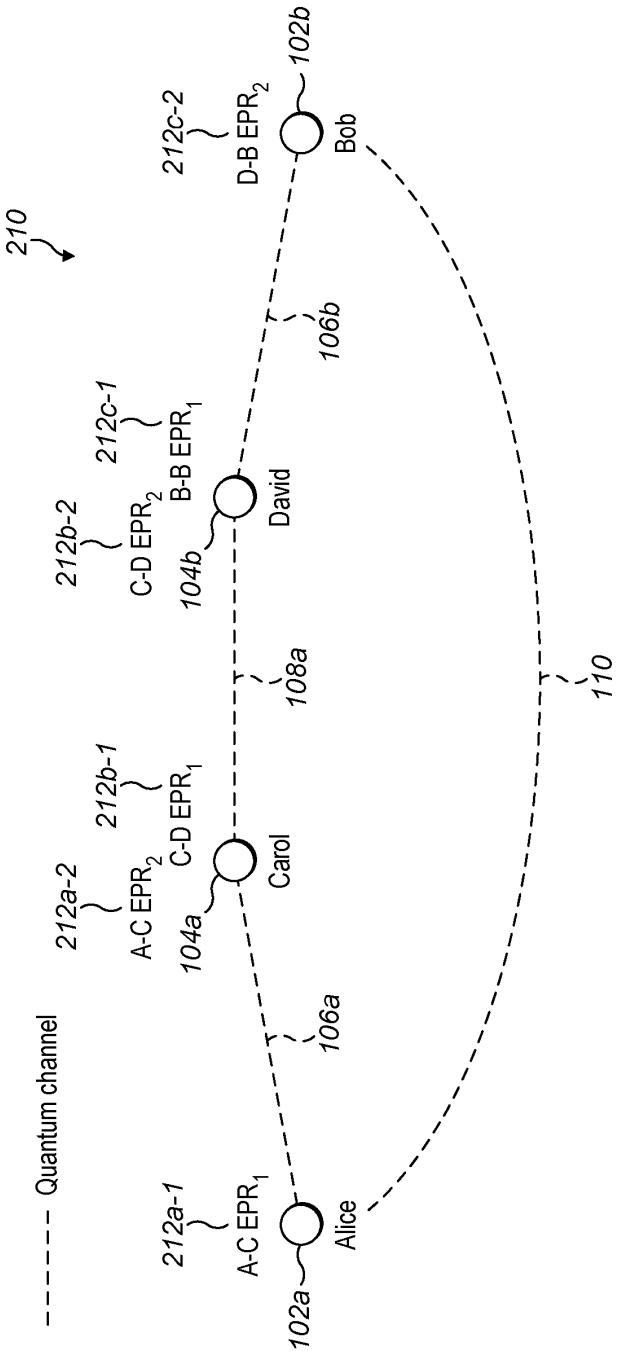

210
Quantum channel
212a-1
A-C EPR1
Alice
102a
212a-2
A-C EPR2
104a
Carol
212b-1
C-D EPR1
212b-2
C-D EPR2
104b
David
212c-1
B-B EPR1
212c-2
D-B EPR2
Bob
102b
106a
106b
108a
110

FIG. 2B

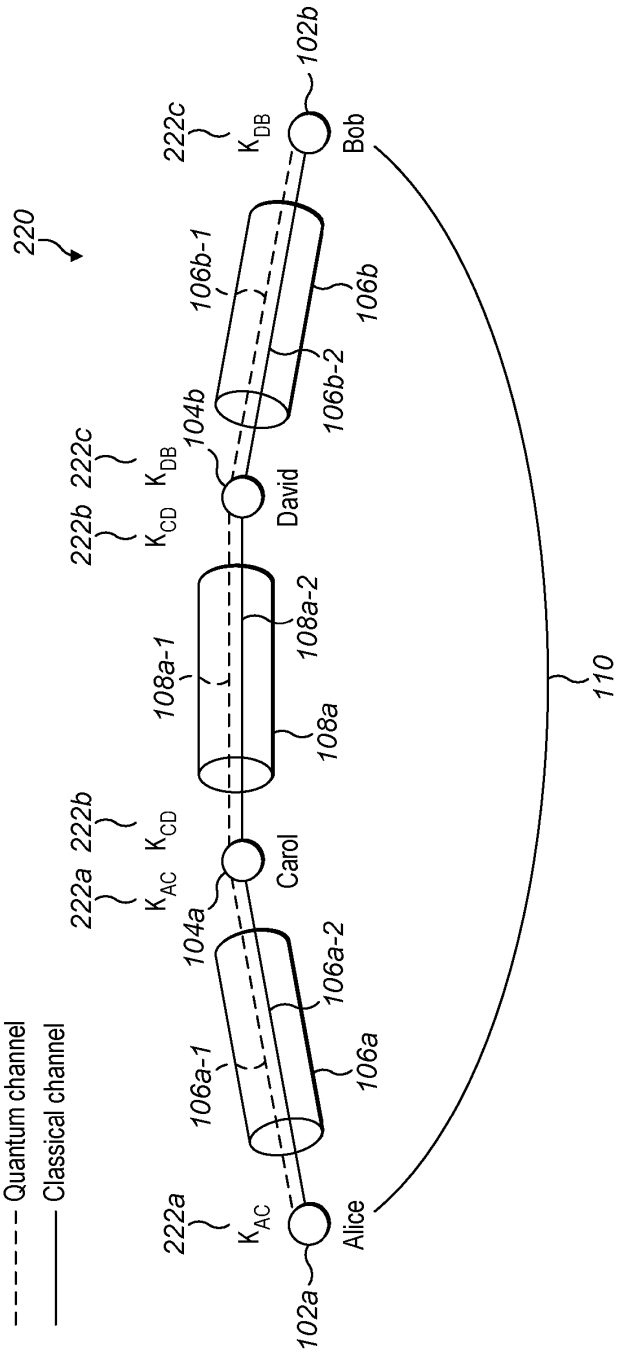

220
Quantum channel
Classical channel
Alice
Bob
Carol
David
102a
102b
104a
104b
106a
106a-1
106a-2
106b
106b-1
106b-2
108a
108a-1
108a-2
110
222a
222b
222c
K_{AC}
K_{CD}
K_{DB}

FIG. 2C

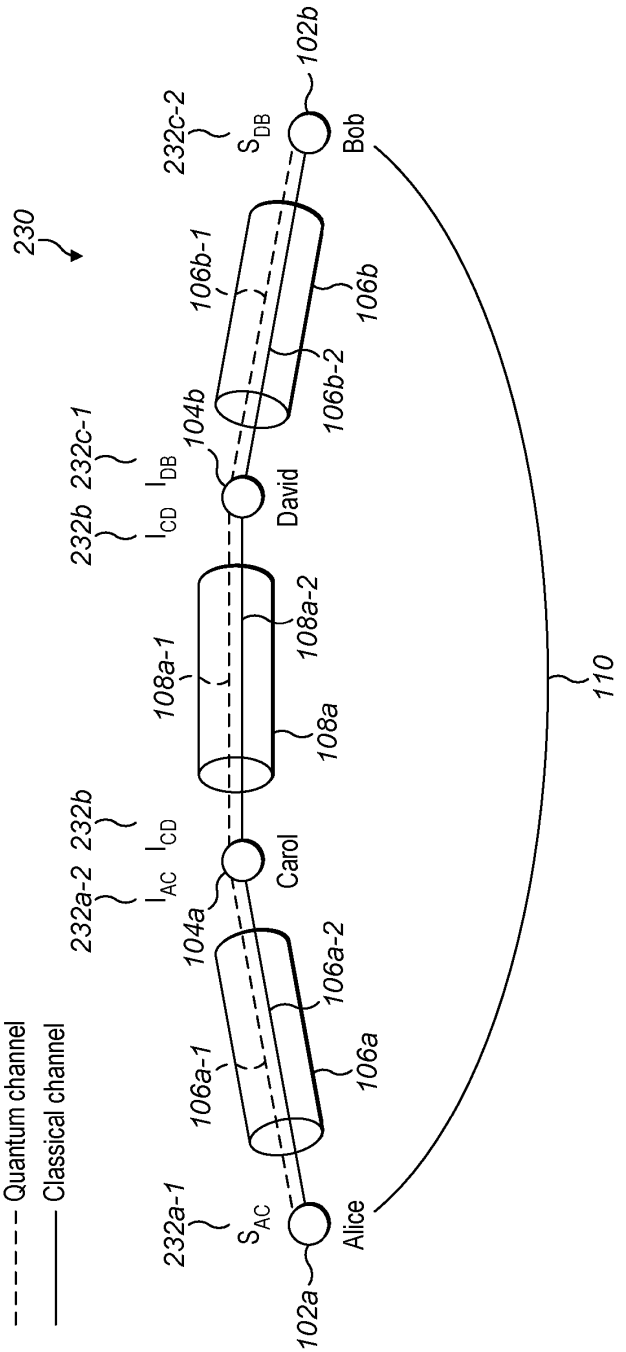

230
Quantum channel
Classical channel
Alice
Bob
Carol
David
102a
102b
104a
104b
110
232a-1
232a-2
232b
232c-1
232c-2
S_{AC}
S_{DB}
I_{AC}
I_{CD}
I_{DB}
106a
106a-1
106a-2
106b
106b-1
106b-2
108a
108a-1
108a-2

FIG. 2D

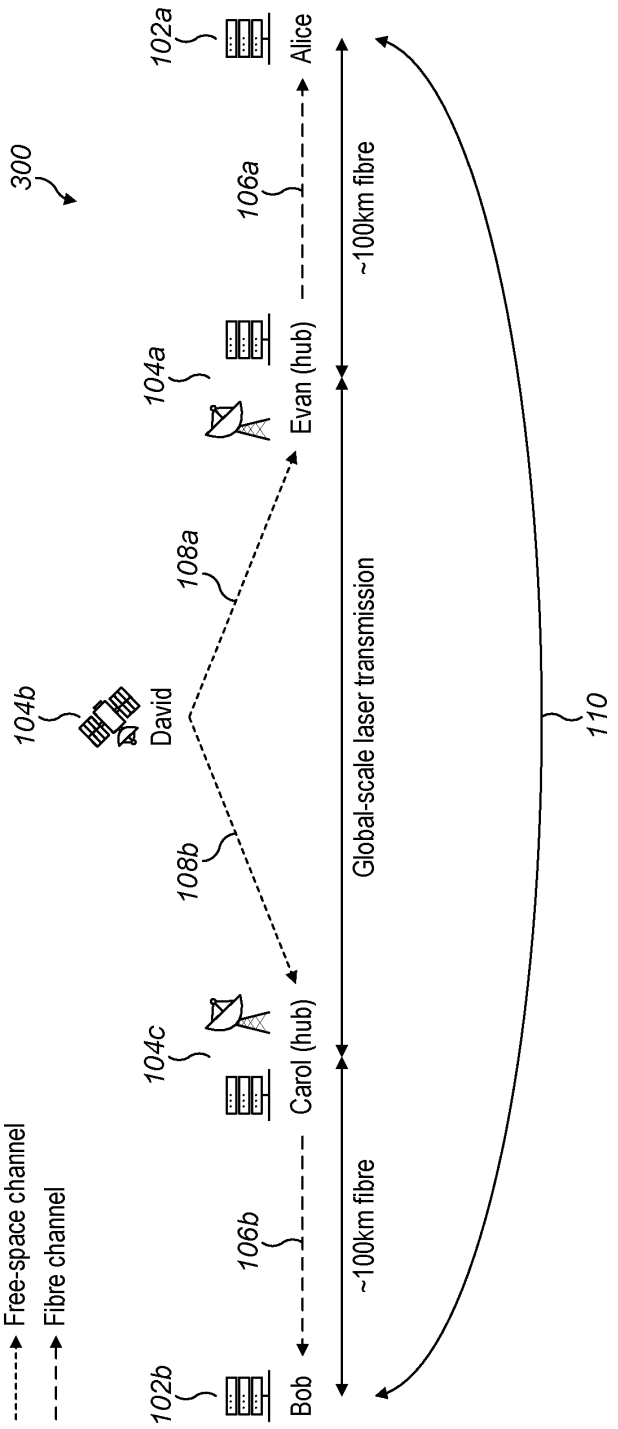

300
102a
Alice
106a
~100km fibre
104a
Evan (hub)
108a
104b
David
108b
Global-scale laser transmission
110
104c
Carol (hub)
106b
~100km fibre
102b
Bob
Free-space channel
Fibre channel

FIG. 3A

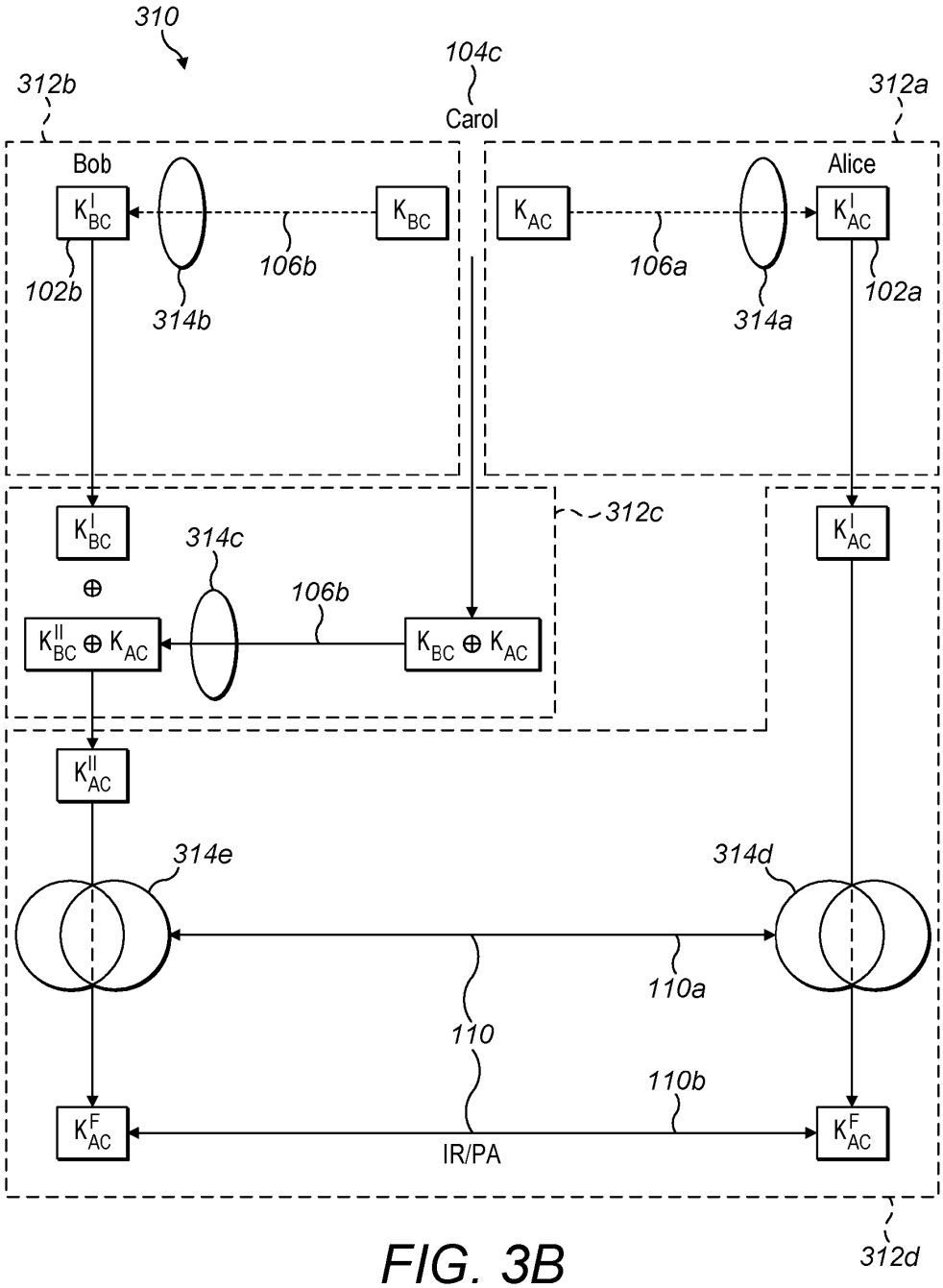

310
104c
Carol
312b
312a
Bob
Alice
K^{I}_{BC}
K_{BC}
K_{AC}
K^{I}_{AC}
102b
314b
106b
106a
314a
102a
312c
K^{I}_{BC}
K^{I}_{AC}
314c
106b
$K^{II}_{BC} \oplus K_{AC}$
$K_{BC} \oplus K_{AC}$
K^{II}_{AC}
314e
314d
110a
110
110b
K^{F}_{AC}
K^{F}_{AC}
IR/PA
312d

FIG. 3B

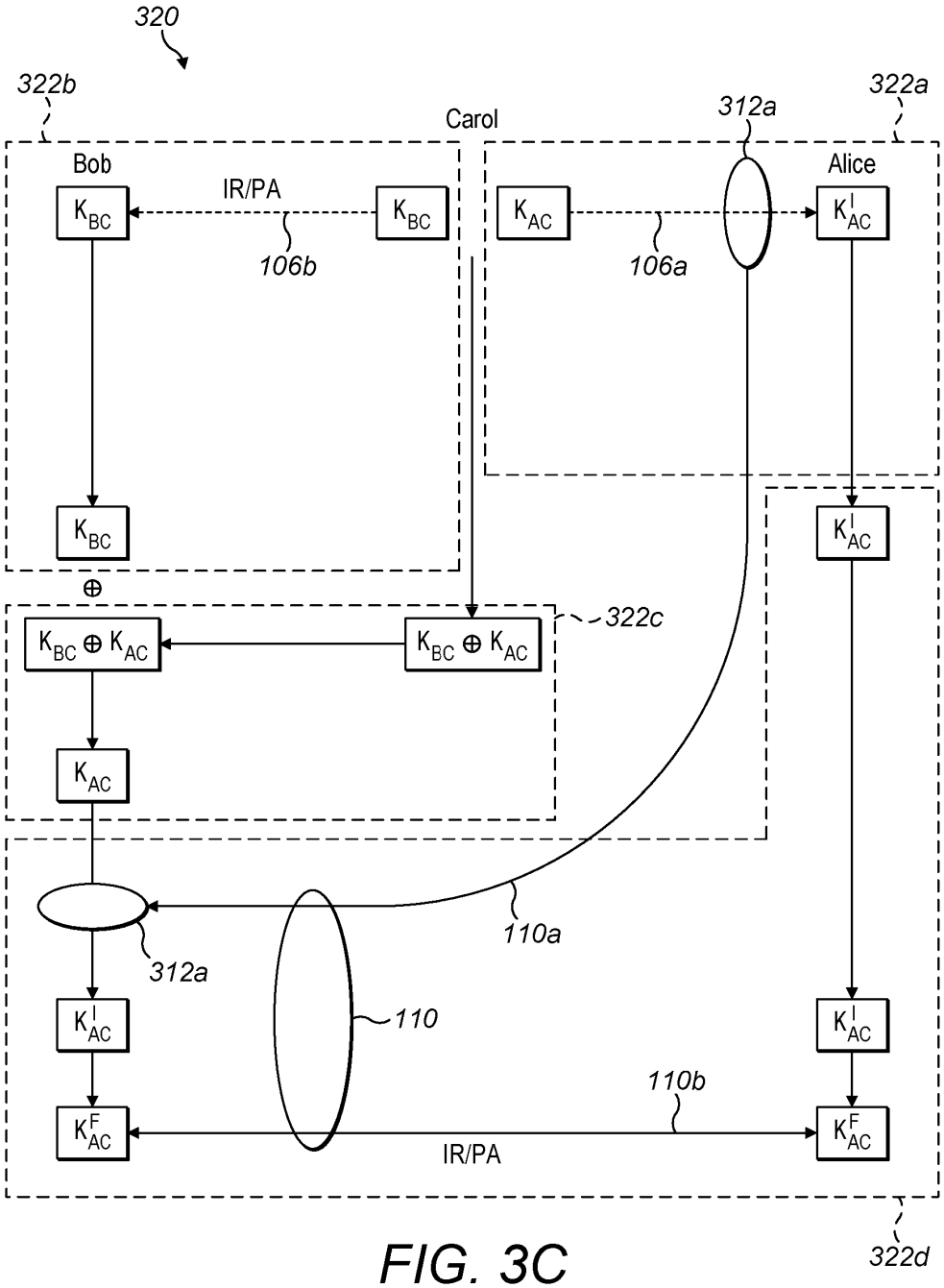

320
322b
Bob
Carol
312a
322a
Alice
IR/PA
106b
106a
322c
110a
312a
110
110b
IR/PA
322d

FIG. 3C

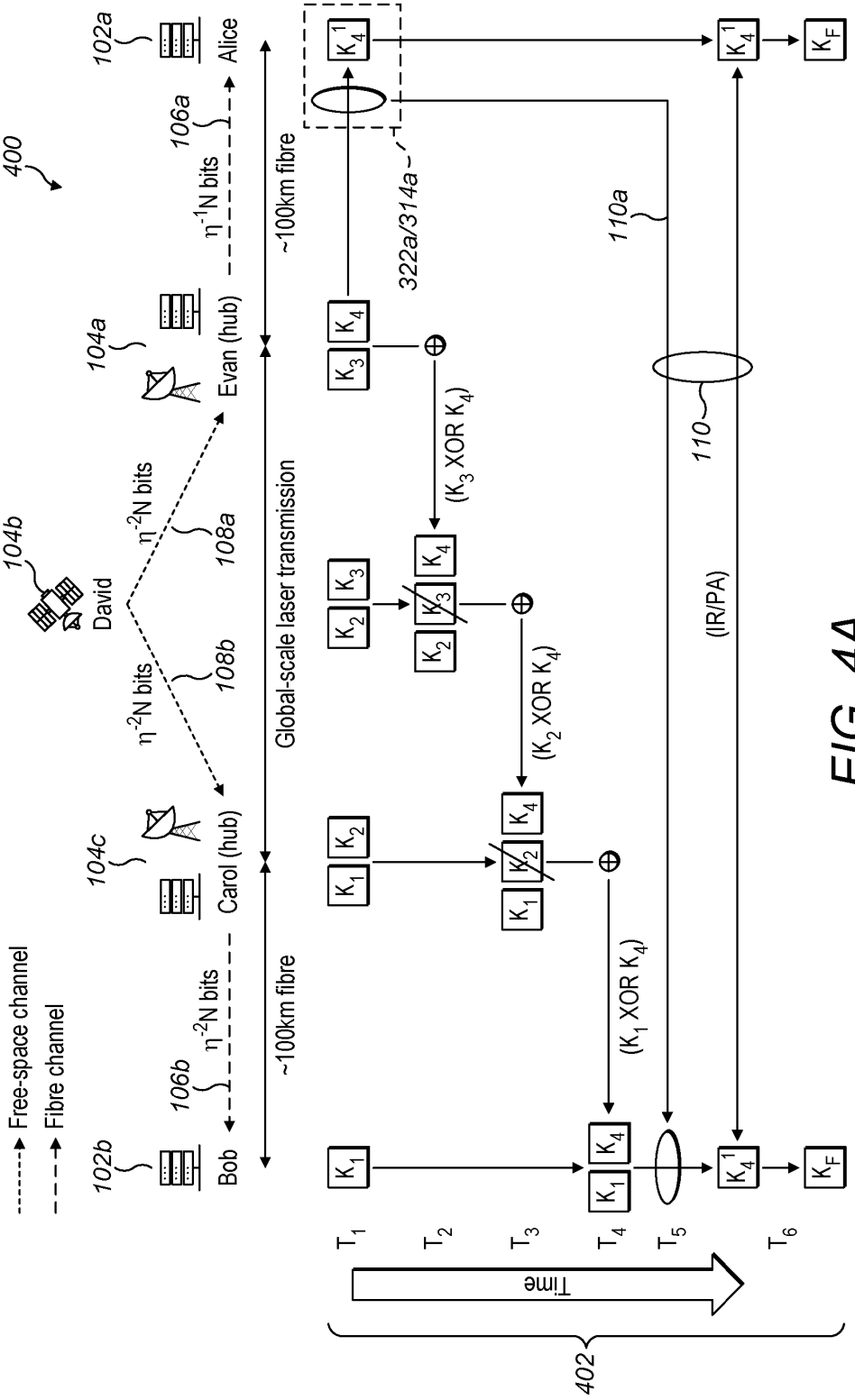

400
102a
Alice
106a
η^{-1}N bits
~100km fibre
104a
Evan (hub)
322a/314a
110a
104b
David
η^{-2}N bits
108a
110
Global-scale laser transmission
η^{-2}N bits
108b
(IR/PA)
104c
Carol (hub)
~100km fibre
106b
η^{-2}N bits
102b
Bob
Free-space channel
Fibre channel
$(K_3 \text{ XOR } K_4)$
$(K_2 \text{ XOR } K_4)$
$(K_1 \text{ XOR } K_4)$
T_1
T_2
T_3
T_4
T_5
T_6
Time
402

FIG. 4A

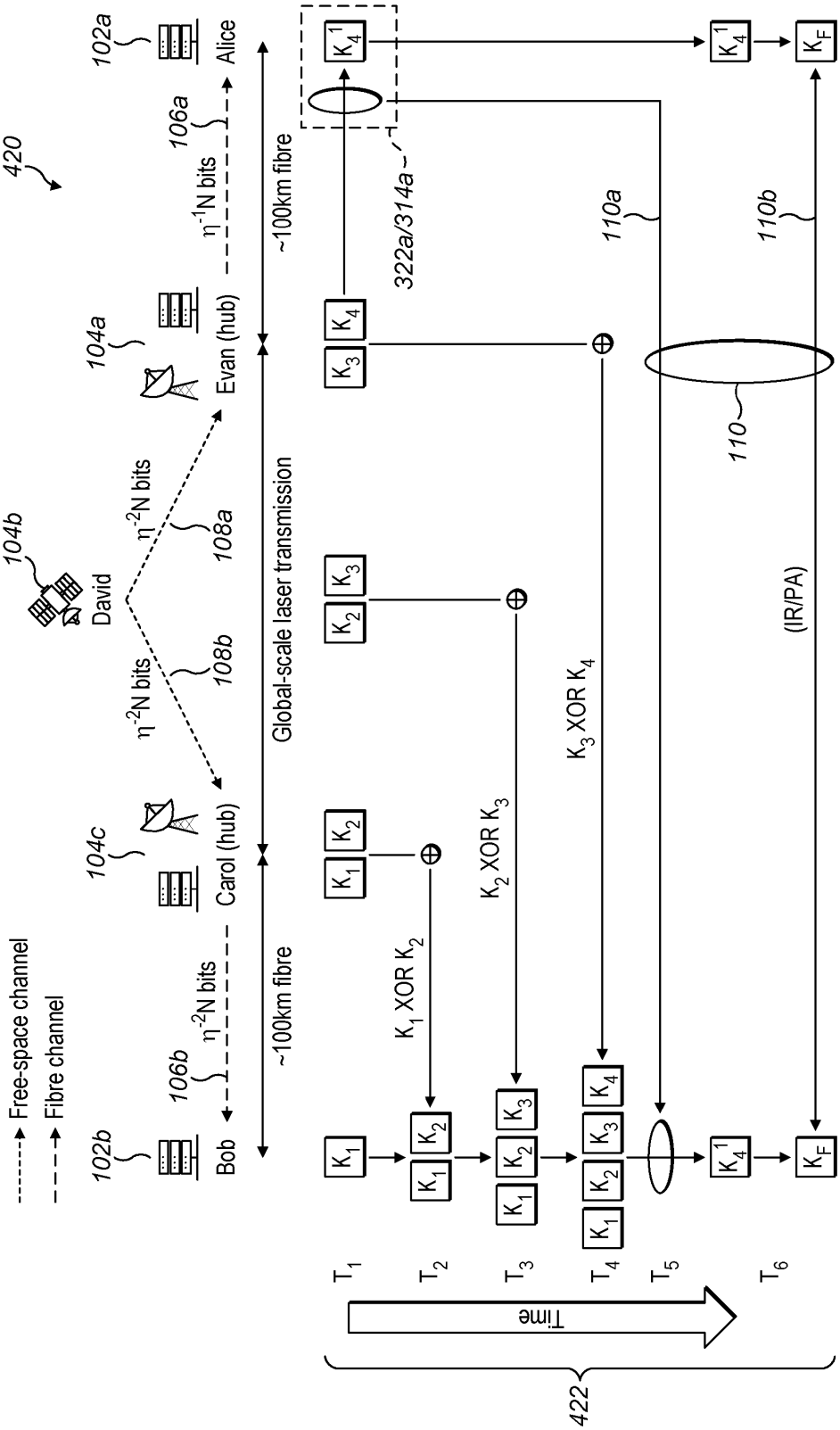

420
102a
Alice
106a
η^{-1}N bits
~100km fibre
104a
Evan (hub)
322a/314a
110a
110b
110
104b
David
η^{-2}N bits
108a
108b
Global-scale laser transmission
104c
Carol (hub)
η^{-2}N bits
106b
~100km fibre
102b
Bob
Free-space channel
Fibre channel
K_1 XOR K_2
K_2 XOR K_3
K_3 XOR K_4
(IR/PA)
K_1
K_2
K_3
K_4
K_4^1
K_F
T_1
T_2
T_3
T_4
T_5
T_6
Time
422

FIG. 4B

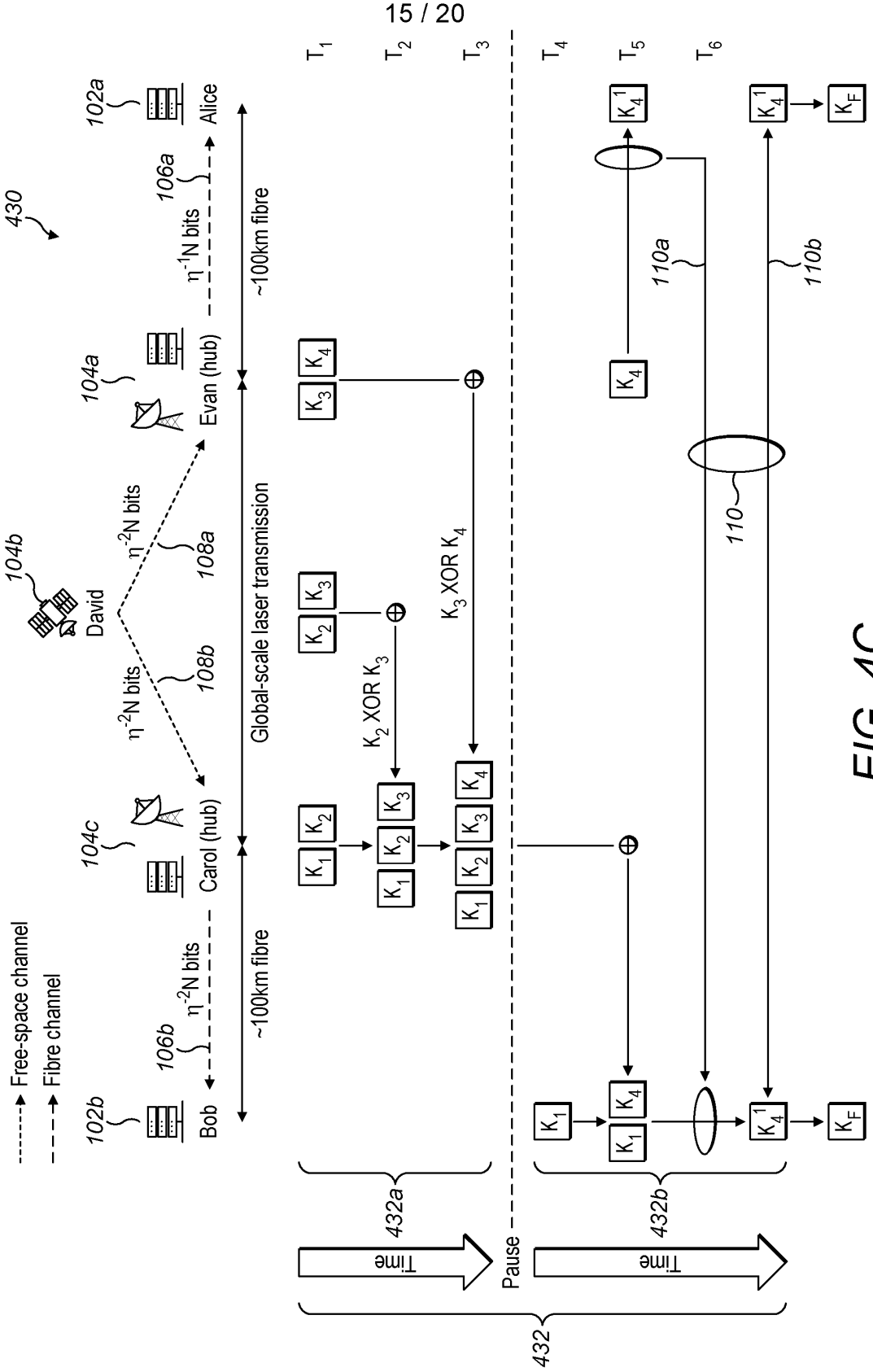

Free-space channel
Fibre channel
430
102a
Alice
106a
η^{-1}N bits
~100km fibre
104a
Evan (hub)
104b
David
η^{-2}N bits
108a
η^{-2}N bits
108b
Global-scale laser transmission
104c
Carol (hub)
106b
η^{-2}N bits
~100km fibre
102b
Bob
T_1
T_2
T_3
T_4
T_5
T_6
K_2 XOR K_3
K_3 XOR K_4
110a
110b
110
432a
432b
Time
Pause
Time
432

FIG. 4C

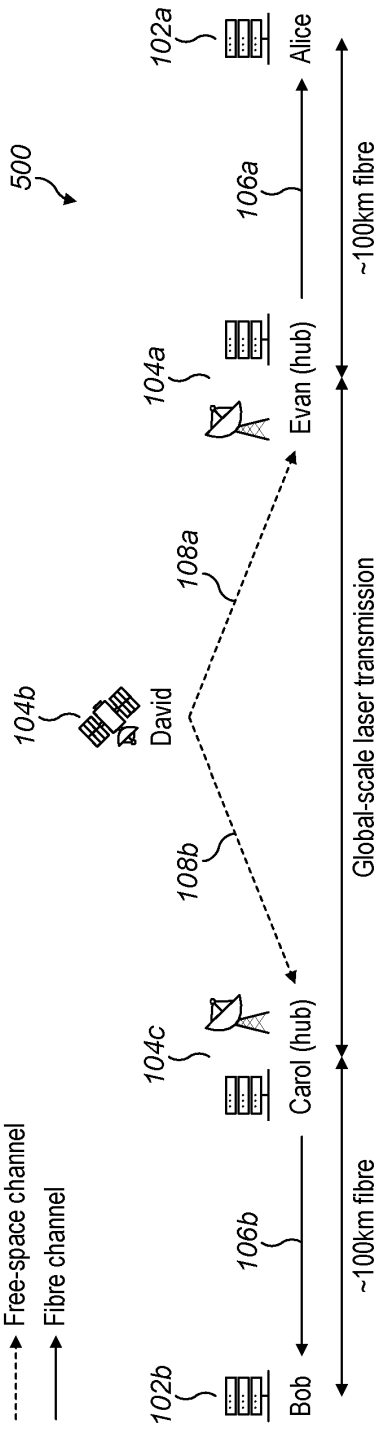

500
102a
Alice
106a
~100km fibre
104a
Evan (hub)
108a
104b
David
108b
Global-scale laser transmission
104c
Carol (hub)
106b
~100km fibre
102b
Bob
Free-space channel
Fibre channel

FIG. 5A

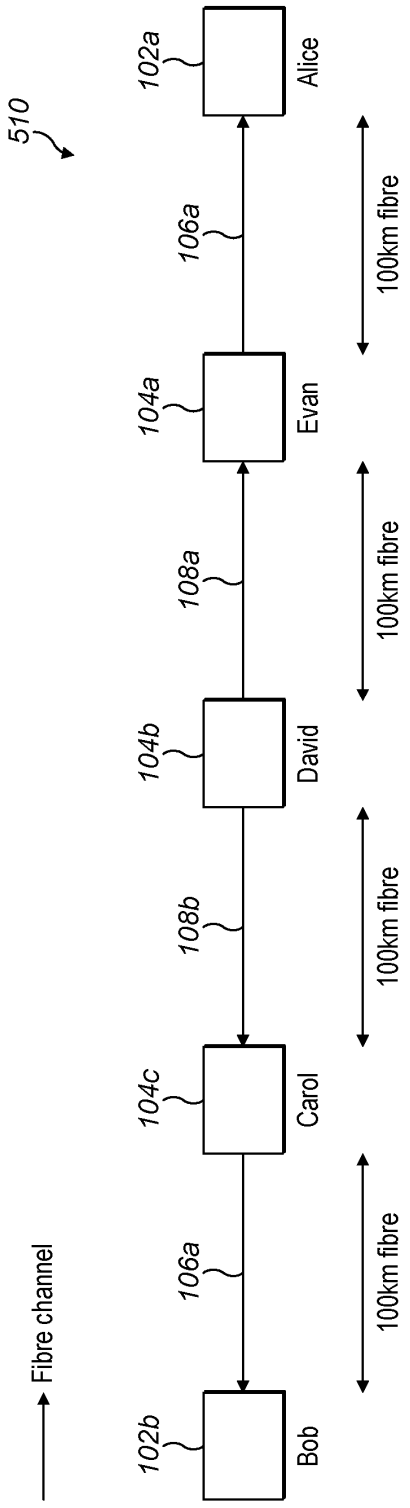

510
102a
Alice
106a
100km fibre
104a
Evan
108a
100km fibre
104b
David
108b
100km fibre
104c
Carol
106a
100km fibre
Fibre channel
102b
Bob

FIG. 5B

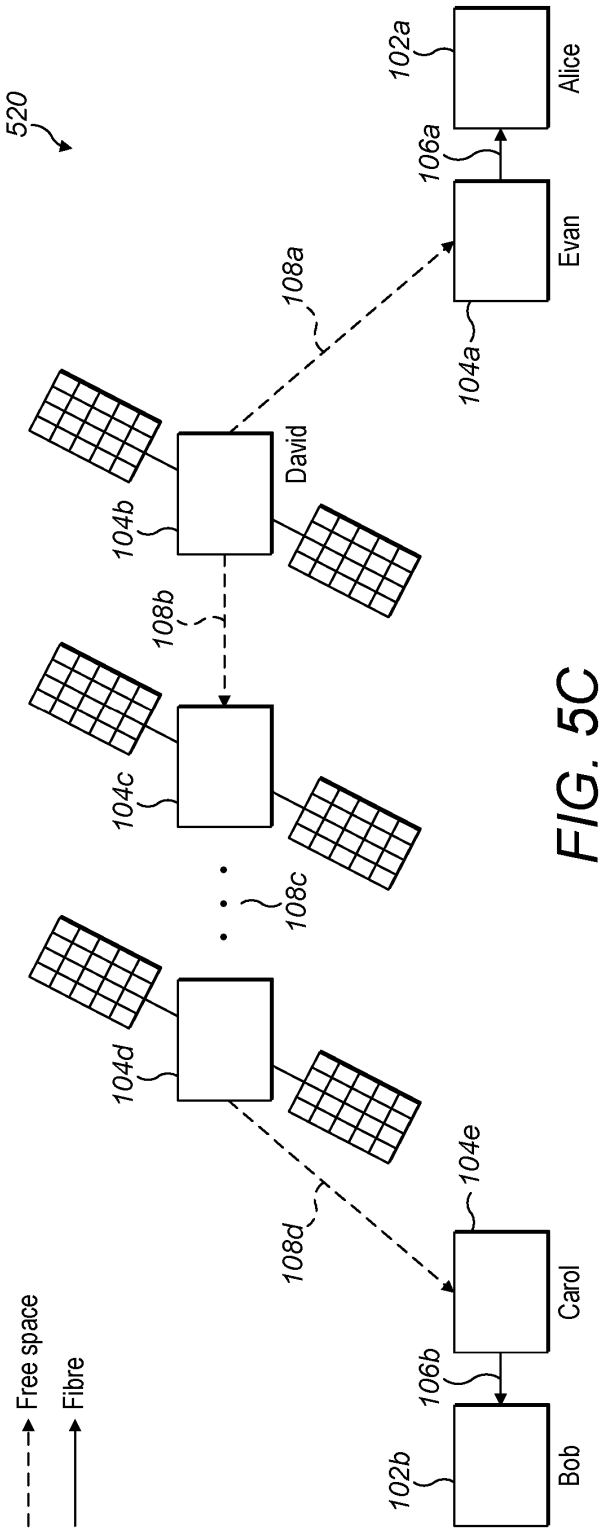

520
102a
Alice
106a
Evan
104a
108a
David
104b
108b
104c
108c
104d
108d
104e
Carol
106b
Bob
102b
Free space
Fibre

FIG. 5C

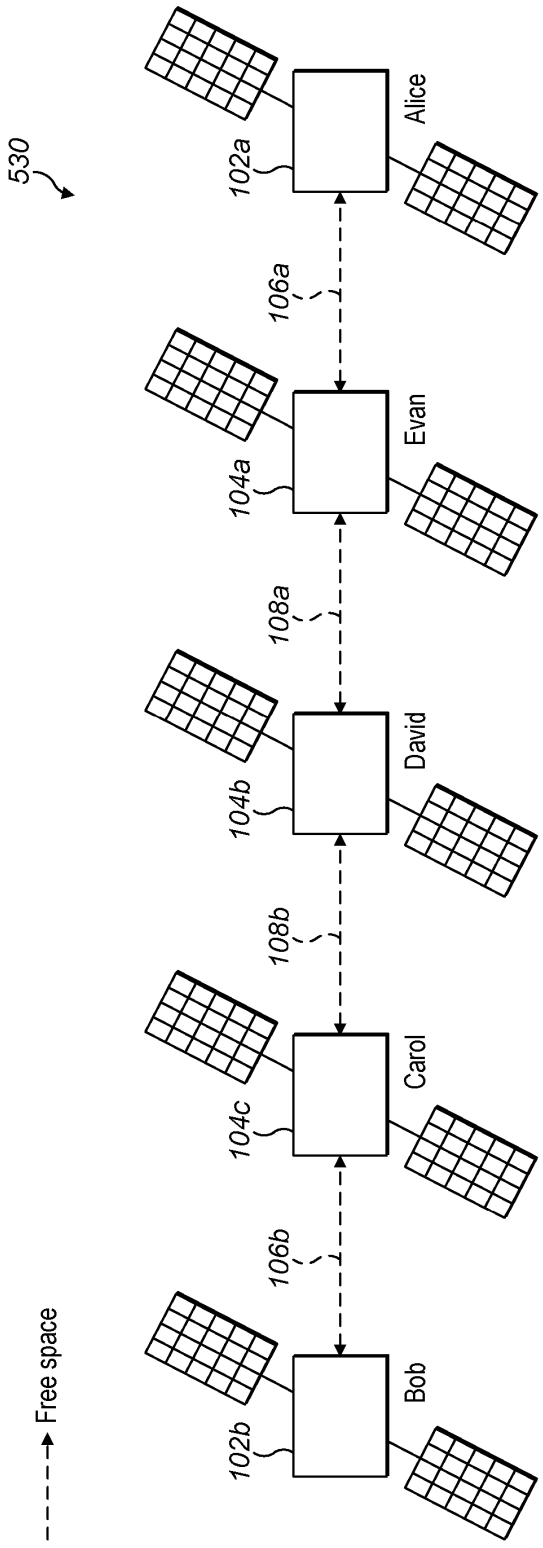

530
Alice
102a
106a
Evan
104a
108a
David
104b
108b
Carol
104c
106b
Bob
102b
Free space

FIG. 5D

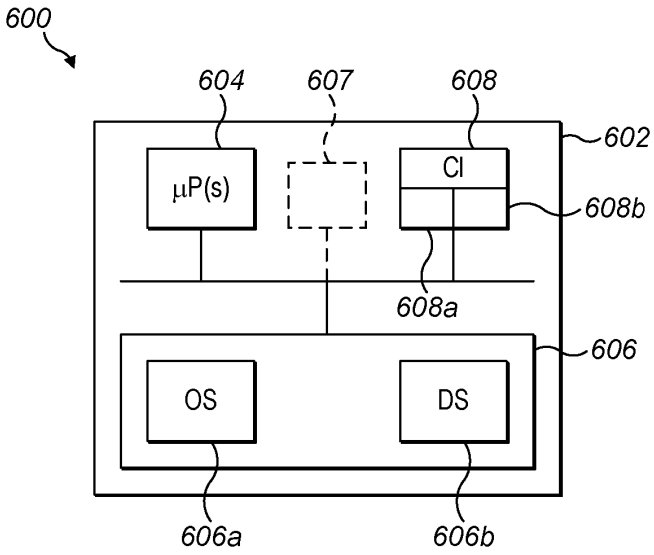

600
604
607
608
602
µP(s)
CI
608b
608a
606
OS
DS
606a
606b

FIG. 6a

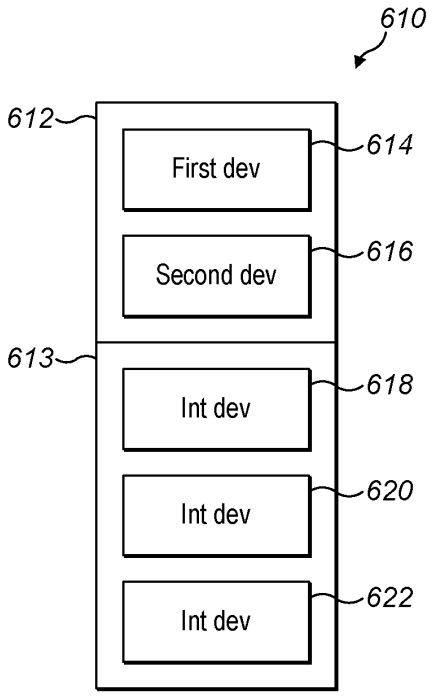

610
612
First dev
614
Second dev
616
613
Int dev
618
Int dev
620
Int dev
622

FIG. 6b