# Wi-Fi Direct: Wi-Fi P2P Connection

# INTRODUCTION

- Wi-Fi direct is new technology
  - enhancing direct device to device communication without requiring a wireless access point.

- Wi-Fi direct builds upon the successful IEEE 802.11 infrastructure mode
  - lets devices negotiate who will take over the AP-like functionalities.

# TECHNICAL OVERVIEW

- In a typical Wi-Fi network, client scans and associate to wireless networks available, which are created and announced by Access Points (AP).

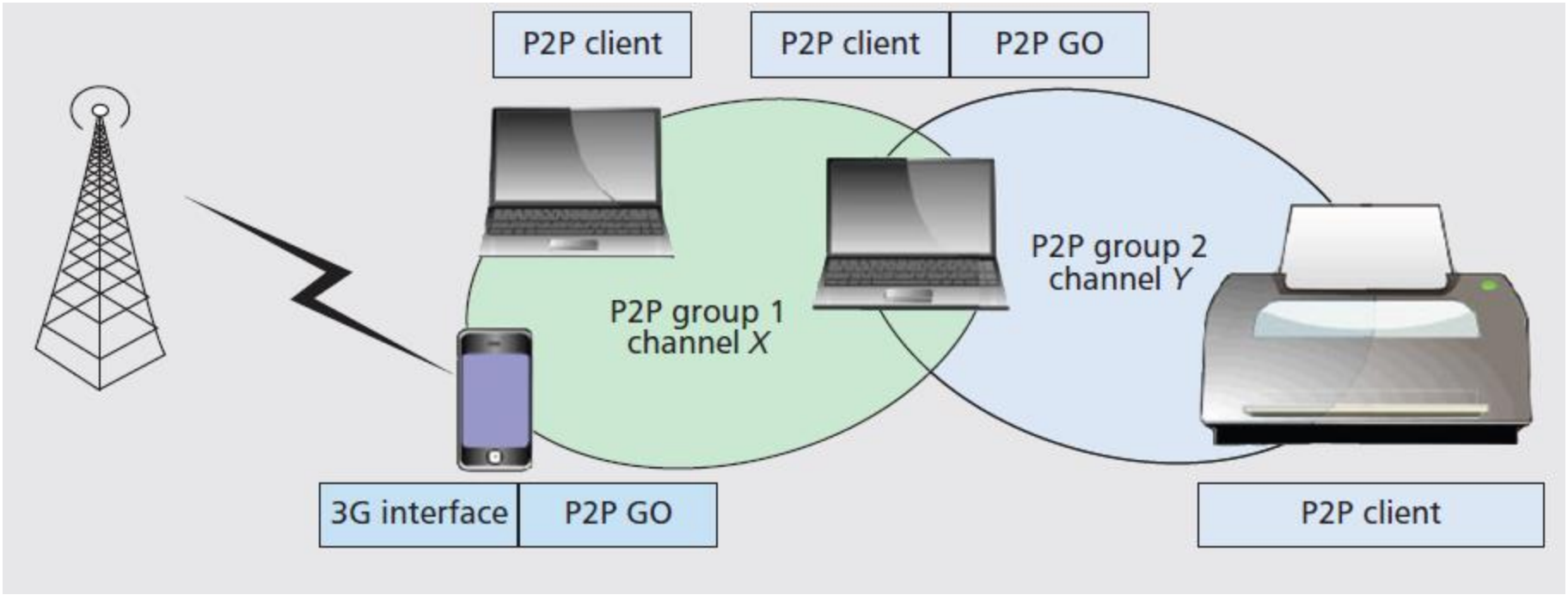
- Wi-Fi Direct is that these roles are specified as dynamic,
  - hence a Wi-Fi Direct device has to implement both the role of a client and the role of an AP.

- These roles are therefore logical roles that could even be executed simultaneously by the same device, this type of operation is called Concurrent mode.

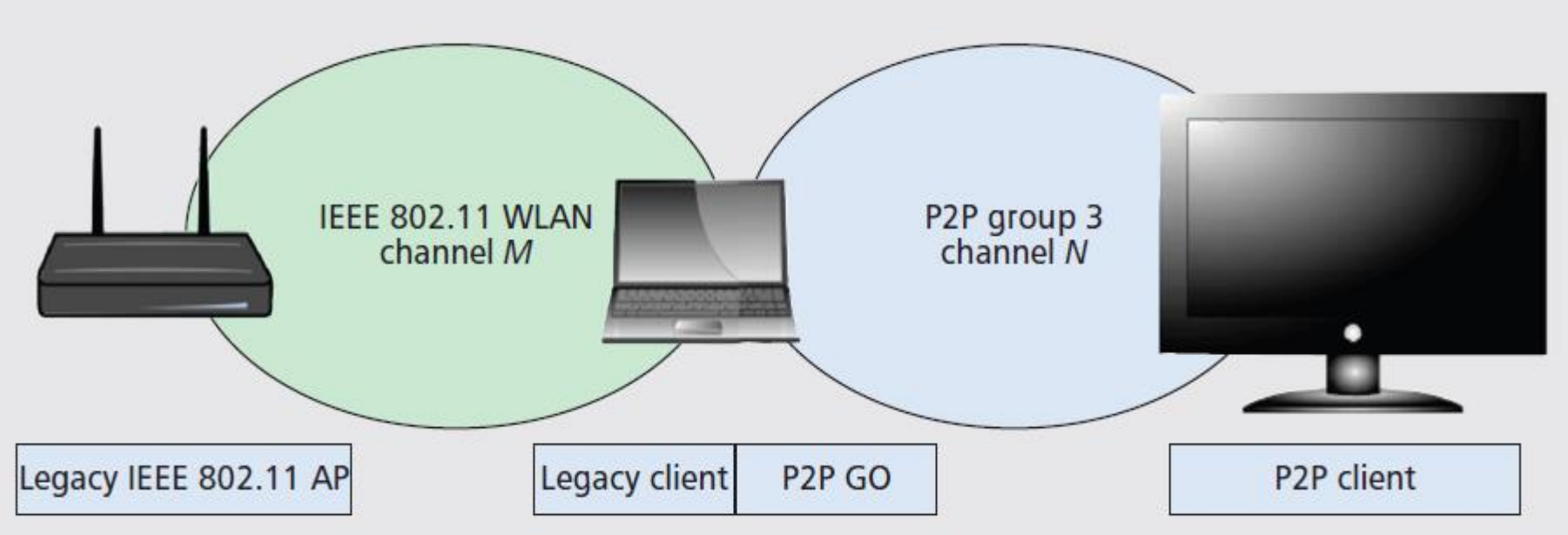
# ARCHITECTURE

- Wi-Fi direct device communicate by establishing P2P group.
- The device implementing AP-like functionality in P2P group is referred to as the P2P Group Owner(P2P GO), and device acting as client are known as P2P clients.
- Once P2P group is established, other P2P clients can join the group as in a traditional Wi-Fi network.
- When the device act as both as P2P client and as P2P GO
  - the device will typically alternate between the two roles by time-sharing the Wi-Fi interface
- Like a traditional AP, a P2P GO announces itself through beacons, and has to support power saving for its associated clients.

# Wi-Fi Direct Setup: Scenario 1



# Wi-Fi Direct Setup: Scenario 2



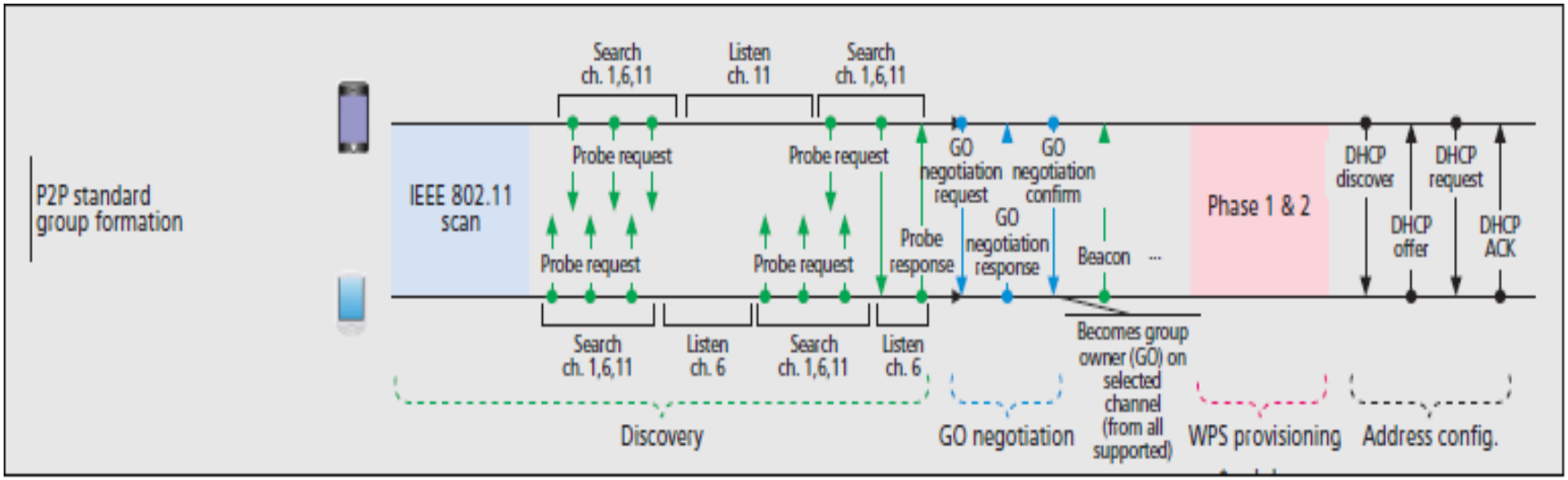
- Only the P2P GO is allowed to cross-connect the devices in its P2P group to an external network.
- Wi-Fi direct does not allow transferring the role of P2P GO within the group.
- If P2P GO leaves the P2P group then the group is break down, and has to re-established.

# GROUP FORMATION

- Three types of group formation techniques
  - Standard
  - Autonomous
  - Persistent
- Group Formation procedure involves two phases-
  - Determination of P2P Group owner
    - Negotiated - Two P2P devices negotiate for P2P group owner based on desire/capabilities to be a P2P GO.
    - Selected - P2P group Owner role established at formation or at an application level
  - Provisioning of P2P Group
    - Establishment of P2P group session using appropriate credentials
    - Using Wi-Fi simple configuration to exchange credentials.

# GROUP FORMATION: Standard

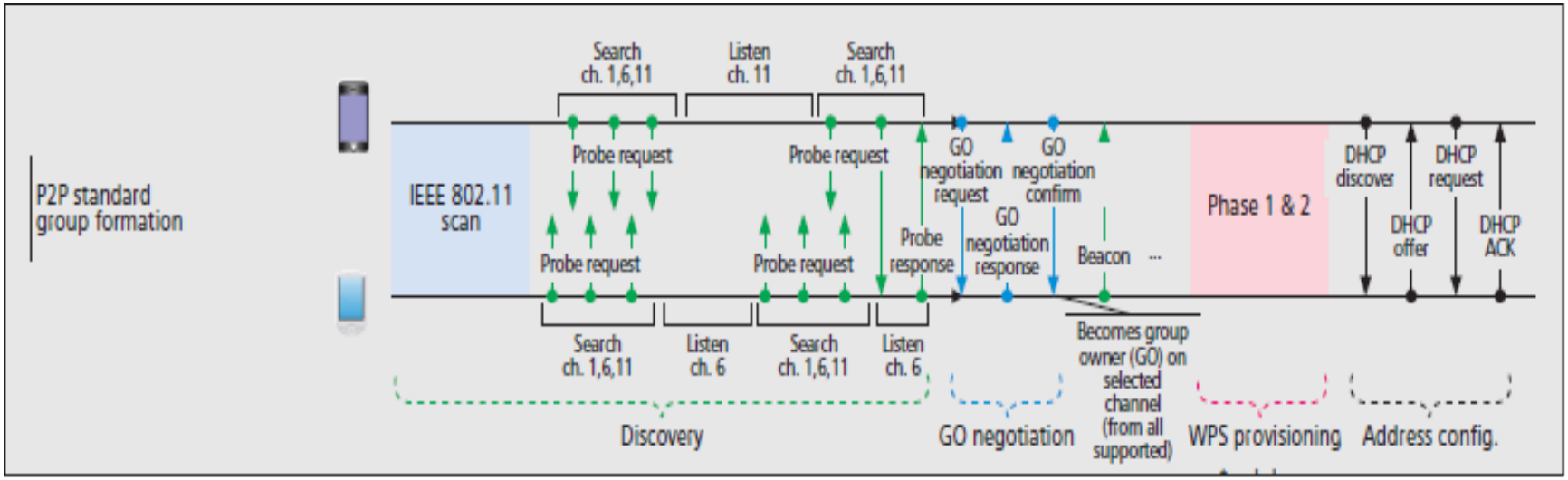
- In this case the P2P device have to discover each other, and then negotiate which device will act as P2P GO.
- Its start by performing a traditional Wi-Fi scan, by means of which they can discover existent groups and Wi-Fi network.




- To prevent conflicts when two devices declare the same GO Intent, a tie-breaker bit is included in the GO Negotiation Request, which is randomly set every time a GO Negotiation Request is sent.

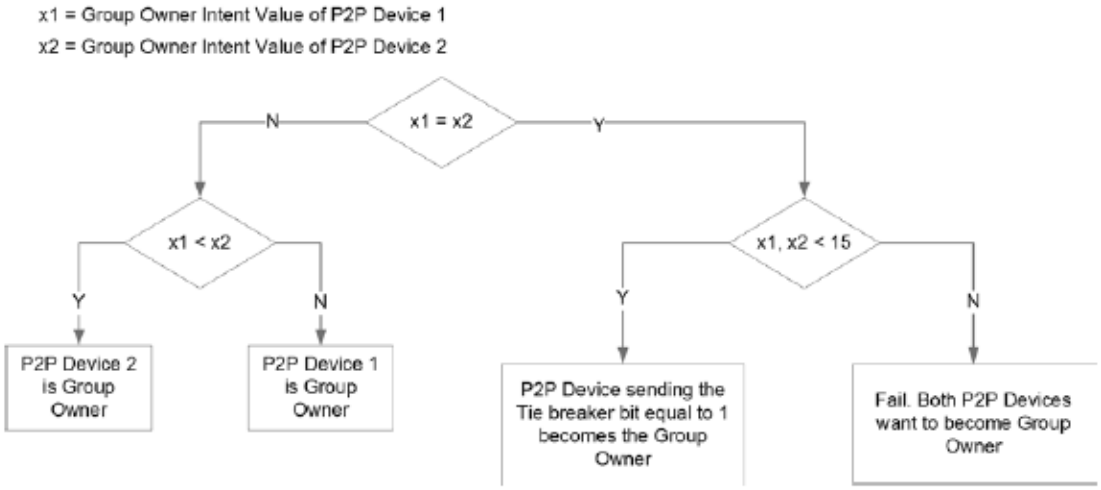
# GROUP FORMATION: Standard

- Discovery algorithm: P2p device selects one of the social channels (2.4 GHz– ch-1, 6, 11)
- Two state – (a) search – sends Probe request
- (b) listen----listens for probe request ---- sends Probe response
- Each state ---------- 100 ms to 300 ms
  - Tradeoff (discovery time with throughput, energy)



# GROUP FORMATION: Standard

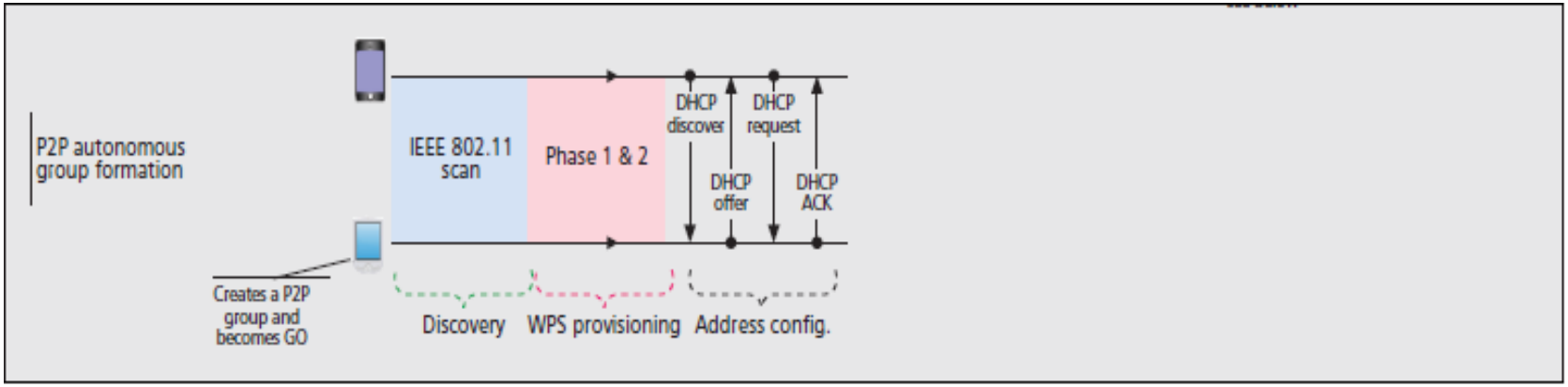
- Select GO----GO negotiation phase
- Three way handshake (request/response/confirmation)
- Selects GO and channel (2.4Ghz, 5Ghz)
- P2p device sends a numerical value --- GO Intent
  - Highest value




- To prevent conflicts when two devices declare the same GO Intent, a tie-breaker bit is included in the GO Negotiation Request,
- Randomly set every time a GO Negotiation Request is sent.

# GROUP FORMATION: Autonomous

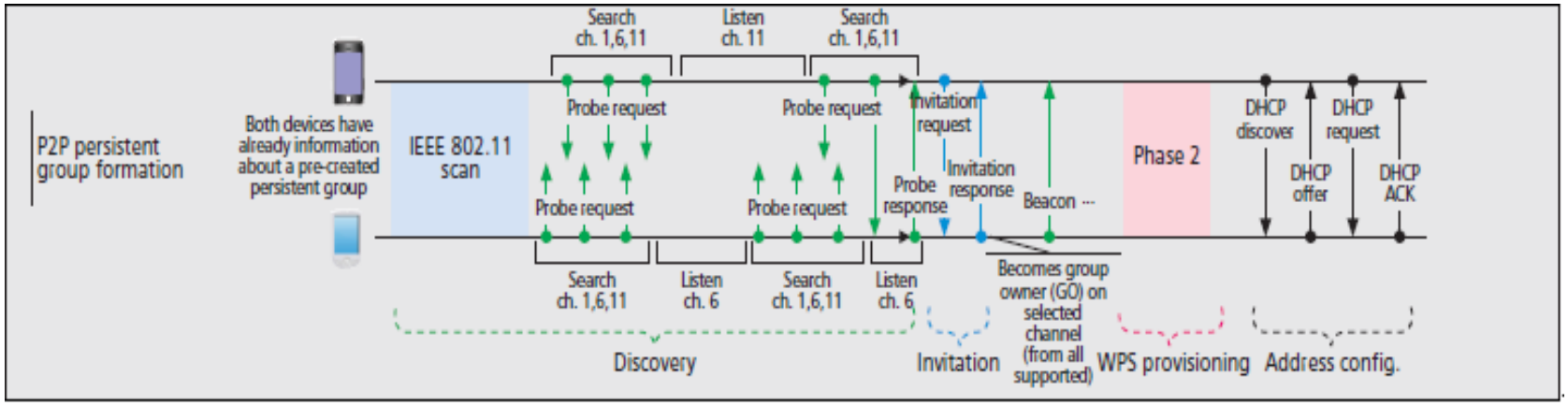
- A P2P device may autonomously create a P2P group,
  - it immediately becomes the P2P GO, by sitting on a channel and starting a beacon.



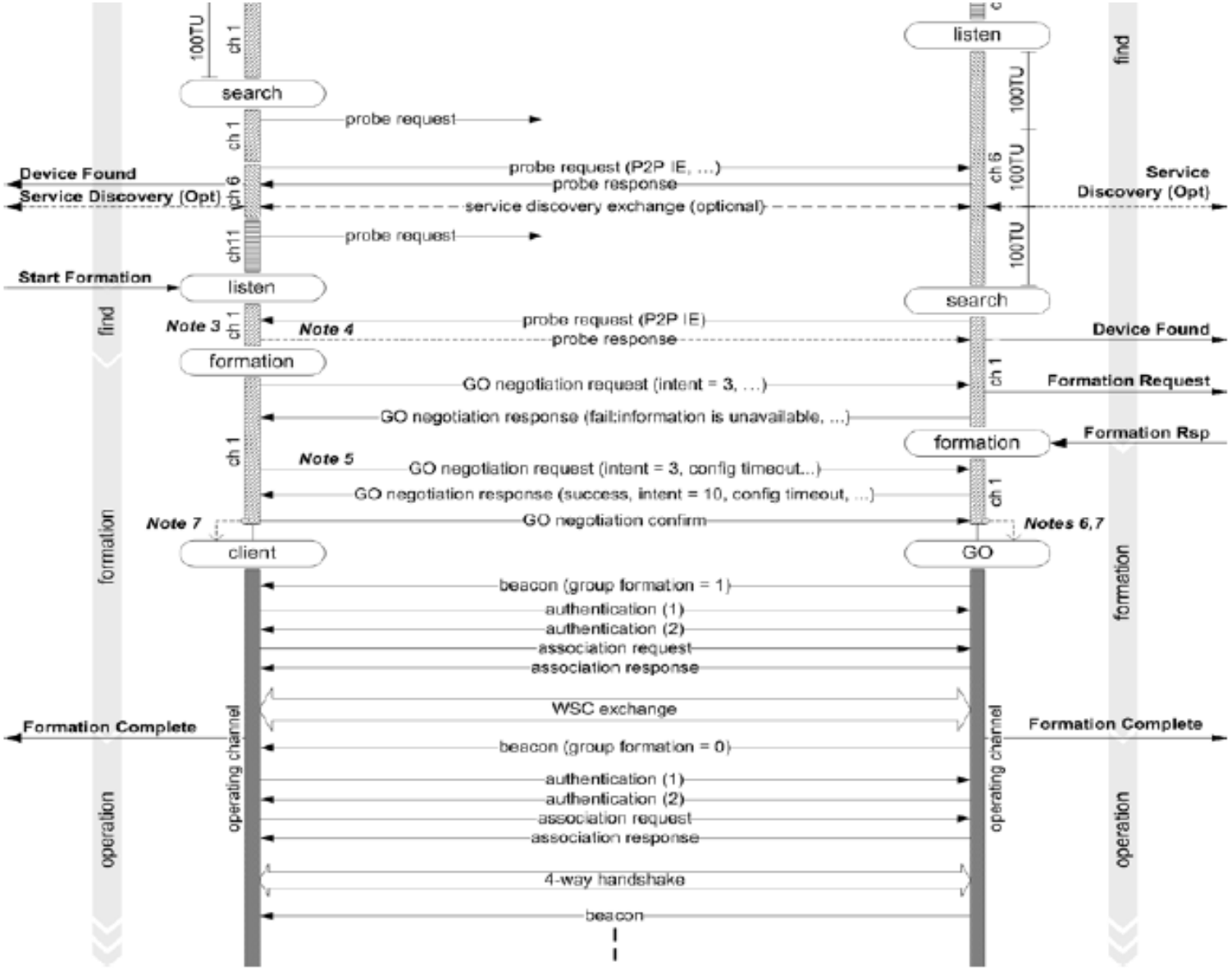

- Other devices can discover the established group using traditional scanning mechanisms.
- As compared to previous case, the discovery phase is simplified
  - the device establishing the group does not alternate between states, and indeed no GO negotiation phase is required.

# GROUP FORMATION: Persistent

- In this process, P2P device can declare a group as persistent, by using flag in the P2P capabilities attribute present in beacon frames.




- After the discovery phase, if a P2P device recognizes to have formed a persistent group with the corresponding peer in the past, any of the two P2P devices can use the Invitation Procedure to quickly re-instantiate the group.

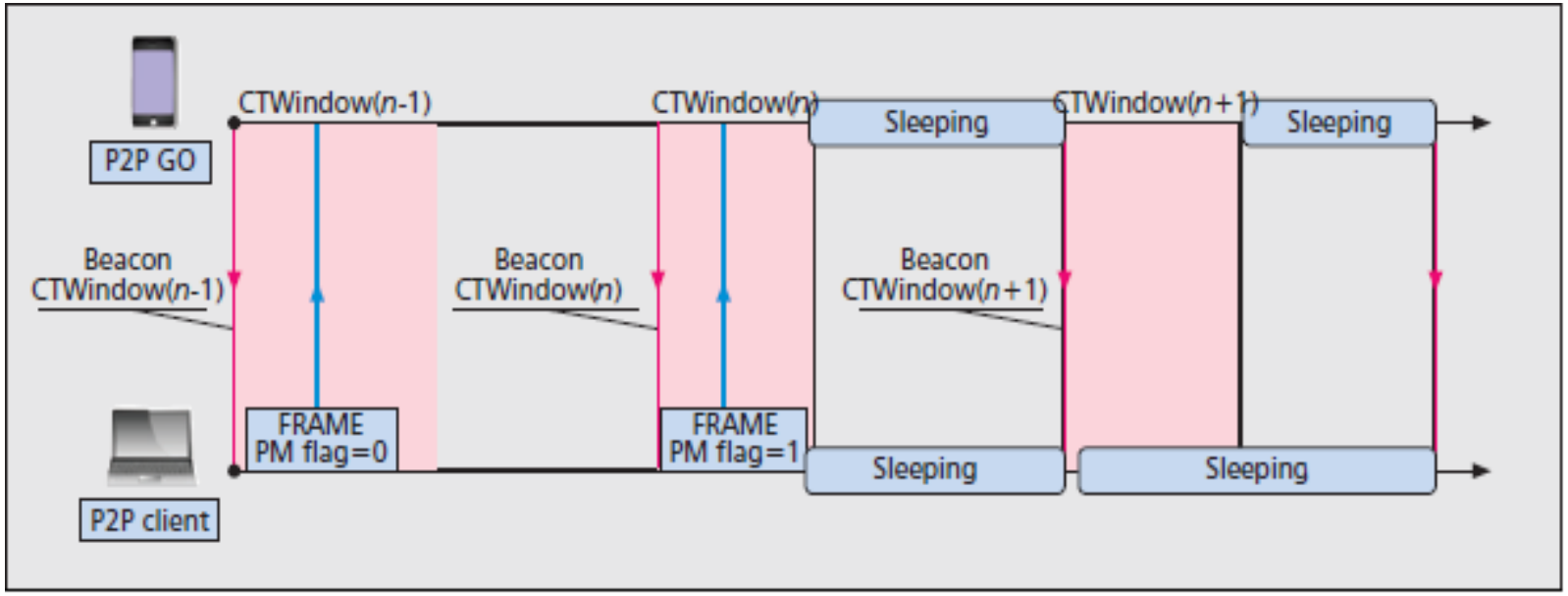

100TU
ch 1
search
probe request
ch 1
Device Found
Service Discovery (Opt)
ch 6
probe request (P2P IE, ...)
probe response
service discovery exchange (optional)
ch11
probe request
Start Formation
listen
find
Note 3
ch 1
Note 4
probe request (P2P IE)
probe response
formation
GO negotiation request (intent = 3, ...)
GO negotiation response (fail:information is unavailable, ...)
ch 1
Note 5
GO negotiation request (intent = 3, config timeout...)
GO negotiation response (success, intent = 10, config timeout, ...)
Note 7
GO negotiation confirm
client
formation
beacon (group formation = 1)
authentication (1)
authentication (2)
association request
association response
WSC exchange
Formation Complete
operating channel
beacon (group formation = 0)
authentication (1)
authentication (2)
association request
association response
4-way handshake
beacon
operation
listen
100TU
ch 6
100TU
100TU
search
find
Service Discovery (Opt)
Device Found
ch 1
Formation Request
formation
Formation Rsp
ch 1
Notes 6,7
GO
formation
Formation Complete
operating channel
operation

# POWER SAVING

- Wifi provides power saving of p2p clients
  - Power management bit
    - Client goes to sleep
  - No option for power saving for AP
- Wi-Fi Direct defines two new power saving mechanisms:
  - Opportunistic Power Save
  - Notice of Absence

# POWER SAVING: Opportunistic Power Save

- P2p clients can move to sleep state
- Allows a P2P GO to save power when all its associated clients are sleeping.
- The P2P Group Owner can only save power when all its clients are sleeping.




Opportunistic power save

# POWER SAVING: Opportunistic Power Save

*Target Beacon Transmission Time*

Traffic indicator map

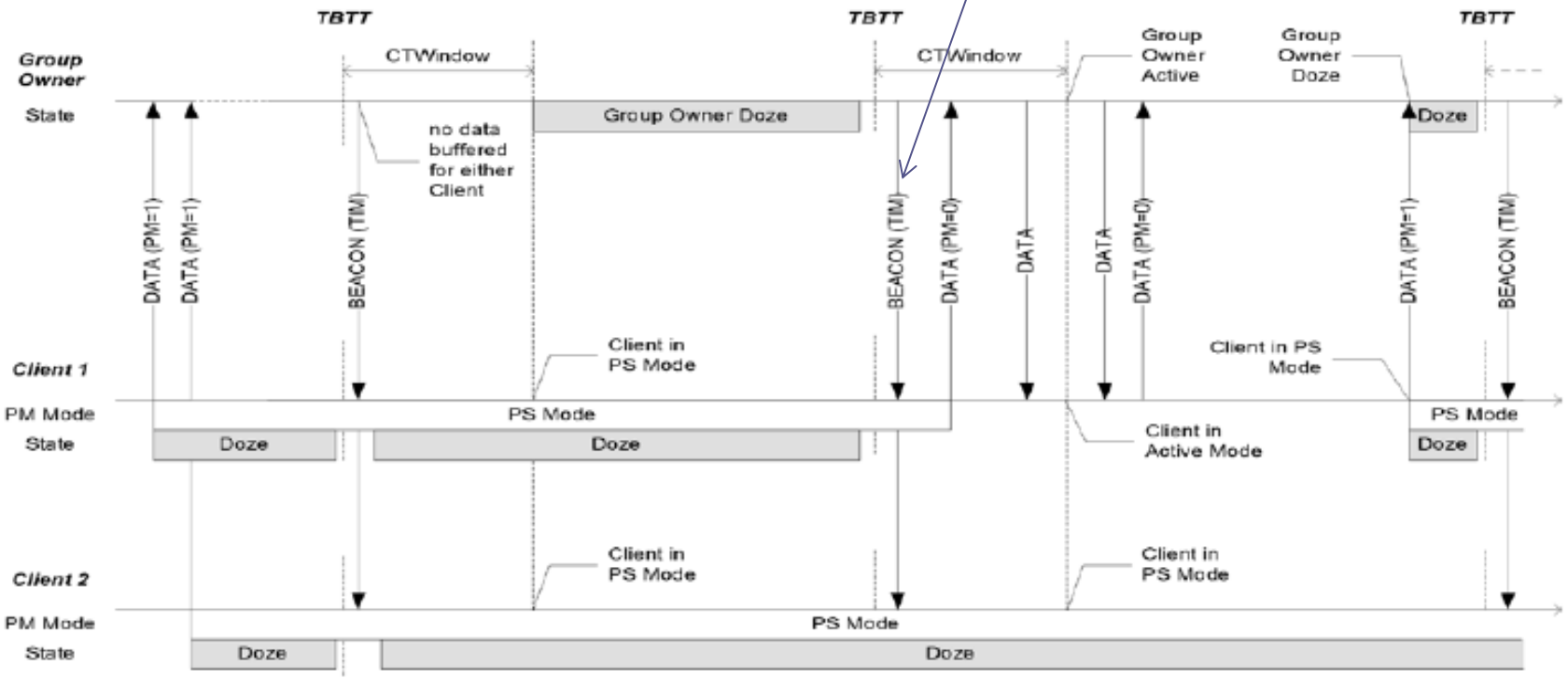
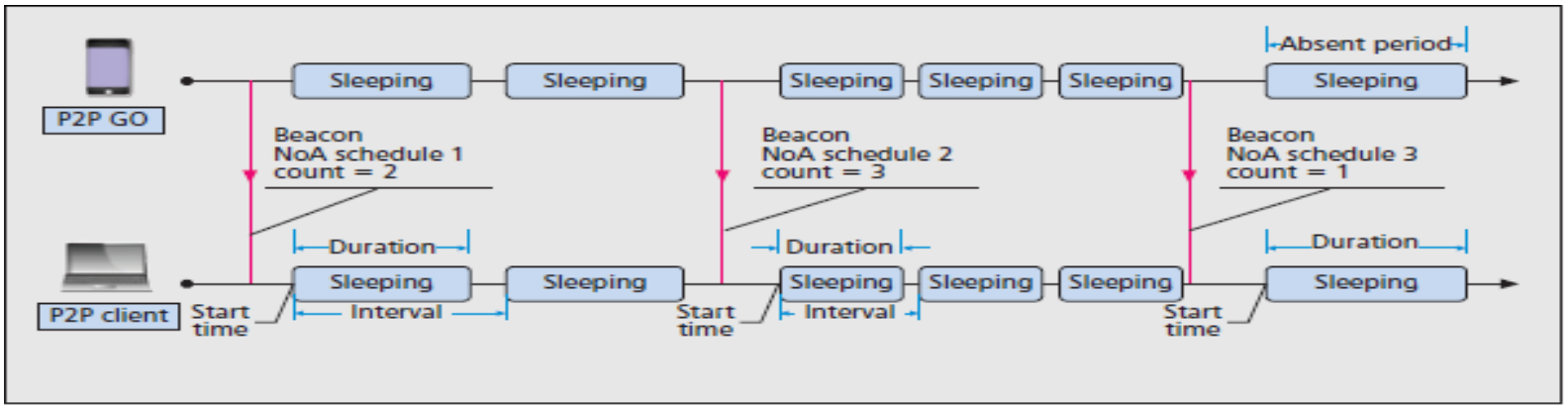


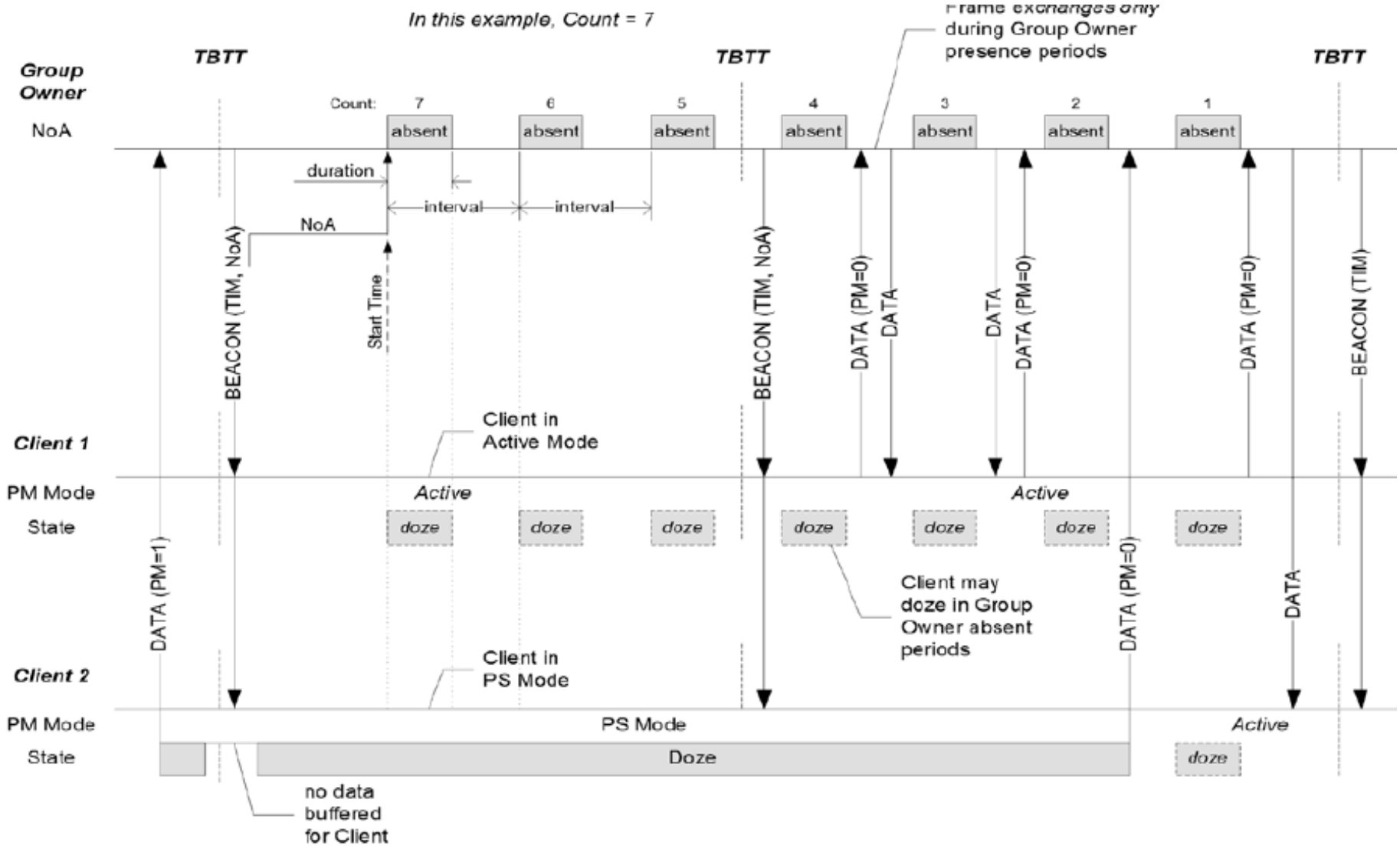

Fig.5. Opportunistic Powersave Operation

# POWER SAVING: Notice of Absence

- This protocol (NoA) allows a P2P GO to announce time intervals, referred to as absence periods, where P2P Clients are not allowed to access the channel.---Beacons, probe response
- P2P GO defines a NoA schedule using four parameters:
  - Duration that specifies the length of each absence period
  - Interval that specifies the time between consecutive absence periods
  - Time that specifies the start time of the first absence period after the current Beacon frame
  - Count that specifies how many absence periods will be scheduled during the current NoA schedule.

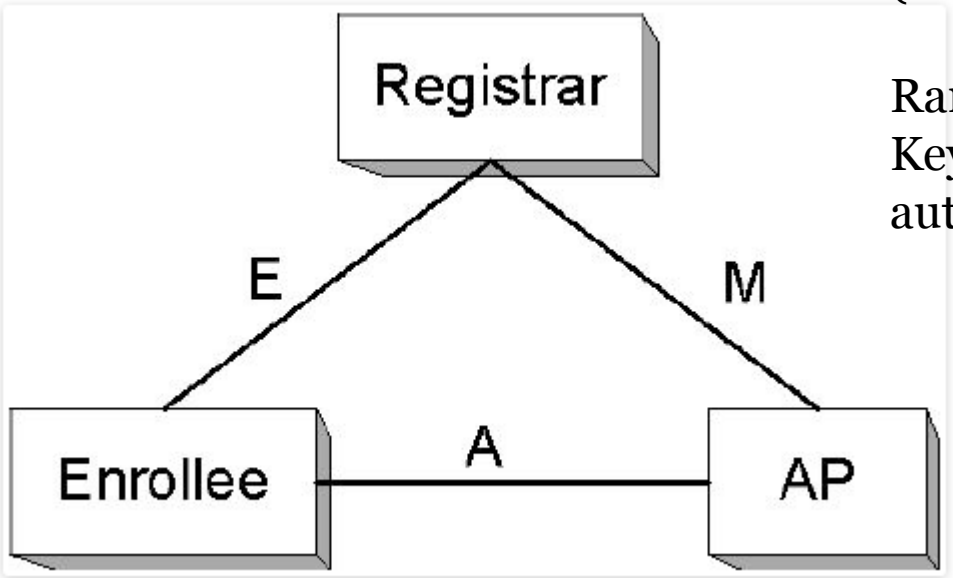



Notice of Absence


In this example, Count = 7
Frame exchanges only during Group Owner presence periods
TBTT
TBTT
TBTT
Group Owner
NoA
Count: 7 6 5 4 3 2 1
absent
duration
interval
interval
NoA
Start Time
BEACON (TIM, NoA)
BEACON (TIM, NoA)
DATA (PM=0)
DATA
DATA
DATA (PM=0)
DATA (PM=0)
BEACON (TIM)
Client 1
Client in Active Mode
PM Mode
State
Active
Active
doze
doze
doze
doze
doze
doze
doze
Client may doze in Group Owner absent periods
DATA (PM=1)
DATA (PM=0)
DATA
Client 2
Client in PS Mode
PM Mode
State
PS Mode
Active
Doze
doze
no data buffered for Client

# SECURITY

- Wi-Fi Direct devices are required to implement Wi-Fi Protected Setup (WPS) to support a secure connection with minimal user intervention.
- WPS allows establishing a secure connection by introducing a PIN in the P2P Client, or pushing a button in the two P2P Devices.
- Following WPS terminology, the P2P GO is required to implement an internal Registrar, and the P2P Client is required to implement an Enrollee.
- The operation of WPS is composed of two parts.
- **In the first part**, the internal Registrar is in charge of generating and issuing the network credentials, i.e., security keys, to the Enrollee
- **In the second part**, the Enrollee (P2P Client) disassociates and reconnects using its new authentication credentials.




Advanced Encryption Standard (AES)-CCMP as cipher,

Randomly generated Pre-Shared Key (PSK) for mutual authentication

# Service discovery protocol

Generic Advertisement Service (GAS) protocol

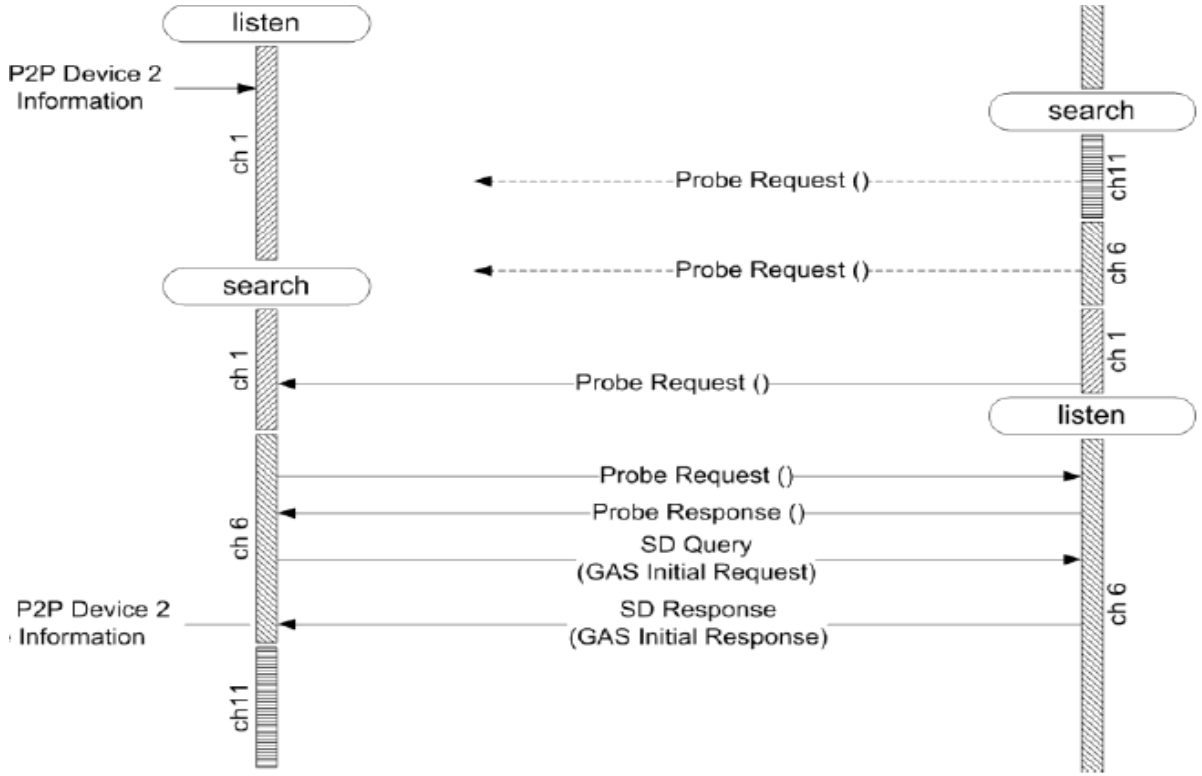
- It may be a single or multiple GAS Initial Request and Response action frame exchange.
- The requesting P2P Device transmits one or more GAS Initial Request frames.
- A target P2P Device that supports Service Discovery responds with one or more GAS Initial Response frames.

- The Service Discovery procedure can be used to find:

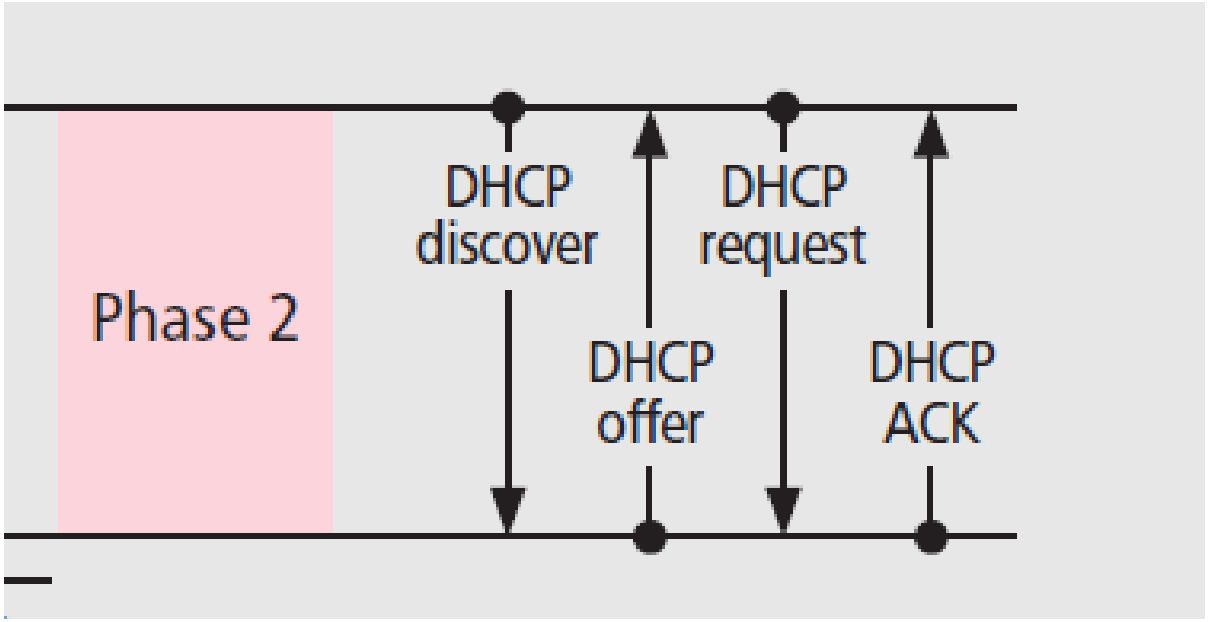
☐ A list of all services offered by a P2P Device
☐ Information about a single service offered by a P2P Device
☐ Information about multiple services offered by a P2P Device
☐ If there has been a change in the services offered by a P2P Device

# Service discovery protocol

Generic Advertisement Service (GAS) protocol



# Address configuration



# CONCLUSIONS

- Wi-Fi alliance has recently developed the Wi-Fi Direct technology that builds upon the Wi-Fi infrastructure mode to enable direct device to device connectivity.
- Thorough overview of the novel technical features specified in Wi-Fi Direct, following by the group formation, and other performance analysis such as power saving and security in this device.
- The NoA protocol could also be re-used to virtualizes the roles of P2P GO/Client over multiple concurrent P2P Groups.
- Concurrent operation together with dynamic nature of the P2P GO/Client roles could be used to improve performance in dense environments, for instance by means of dynamic relays.