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BTLE Triggered WFDS-A Software Approach

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Abstract— BTLE is a low data rate wireless communication technology that uses low power as a result, BTLE link for device to device service discovery. However BTLE has low range and provides a low throughput. Wi-Fi Direct (Wi-Fi P2P) has a high range and provides a high throughput. However Wi-Fi Direct needs high power and a high setup (discovery) time.

Wi-Fi Direct Services (WFDS) are services that run on Wi-Fi Direct to enable users to aware of the various services available on a device. Core idea behind of this research is to use the service discovery process of Bluetooth Low Energy is used in first stage of Wi-Fi Direct service (WFDS) Discovery process while retaining the rest of the stages of WFDS as they are, so as to make service discovery process power efficient in battery constrained devices without compromising on the high throughput available using Wi-Fi Direct.

Keywords—BTLE, Wi-Fi Direct, WFDS, Wi-Fi P2P, 802.11

I. INTRODUCTION

Bluetooth wireless technology is a short-range communications system intended to replace the cable(s) connecting portable and/or fixed electronic devices. The key features of Bluetooth wireless technology are robustness, low power consumption, and low cost. There are two forms of Bluetooth wireless technology systems: Basic Rate (BR) and Low Energy (LE) [1]. Both systems include device discovery, connection establishment and connection mechanisms. The LE system includes features designed to enable products that require lower current consumption, lower complexity and lower cost than BR/EDR. The LE system is also designed for use cases and applications with lower data rates and has lower duty cycles.

WFDS is a standard specification defined by the Wi-Fi alliance [2], which is built on current standard Wi-Fi direct. WFDS specification defines an architecture, protocols and functionality for interoperability of Wi-Fi Direct Services (WFDS). The WFDS enabled system can have multiple ASP-sessions between two or more devices needing the WFDS functionalities. Service is a process that provides standardized functionality to other services or applications. Service on a device will communicate with a similar service on one or more devices using a common protocol. Among the Services, Wi-Fi alliance defined major services namely; Send, Play, Display and Print services.

II. BTLE TERMINOLOGY

A Bluetooth Low Energy device can communicate with the outside world in two ways: Broadcast and Connection.

A. *Broadcasting and Observing*

Using broadcasting, you can send data out to any scanning device or receiver in listening range. As illustrated in Fig. 1 this mechanism essentially allows you to send data out one-way to anyone or anything that is capable of picking up the transmitted data.

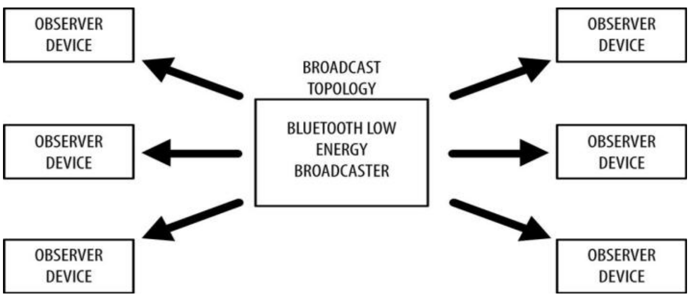

Fig. 1 Broadcasting Topology

1) *Broadcaster*

Sends non-connectable advertising packets periodically to anyone willing to receive them.

2) *Observer*

Repeatedly scans the preset frequencies to receive any non-connectable advertising packets currently being broadcasted.

Broadcasting is important to understand, because it's the only way for a device to transmit data to more than one peer at time. Broadcast data sent out by taking advantage of the advertising features of BTLE. The standard advertising packet contains a 31-byte payload used to include data that describes the broadcaster and its capabilities, but it can also include any custom information you want to broadcast to other devices. If this standard 31-byte payload isn't large enough to fit all of the required data, BTLE also supports an optional secondary advertising payload (called the Scan Response), which allows devices that detect a broadcasting device to request a second advertising frame with another 31-byte payload, for up to 62 bytes total. Broadcasting is fast and easy to use, and it's a good choice if small amount of data needs to be pushed on a fixed schedule or to multiple devices.

A major limitation of broadcasting, when compared to a regular connection, is that there are no security or privacy provisions at all with it (any observer device is able to receive the data being broadcasted), so it might not be suited for sensitive data.

B. Connection

To transmit data in both directions between the devices, or if there is more data than the two advertising payloads can accommodate, there is need to use a connection. A connection is a permanent, periodical data exchange of packets between two devices. It is therefore inherently private (the data is sent to and received by only the two peers involved in a connection, and no other device unless it's indiscriminately sniffing).

Connection involves two separate roles:

1) Central: Repeatedly scans the preset frequencies for connectable advertising packets and, when suitable, initiates a connection. Once the connection is established, the central device manages the timing and initiates the periodical data exchanges.

2) Peripheral: A device that sends connectable advertising packets periodically and accepts incoming connections. Once in an active connection, the peripheral follows the central's timing and exchanges data regularly with it.

III. WI-FI DIRECT AND WFDS TERMINOLOGY

Wi-Fi Direct is Wi-Fi Alliance's new ad-hoc communication protocol for interconnecting smart devices, by allowing setup a "soft access point" for high bandwidth Wi-Fi communication. Wi-Fi Direct requires a secure pairing procedure which adds delay (up to two minutes). It was designed for different purposes and without energy efficiency in mind. The discovery process is very costly and requires both devices to actively scan at the same time for a successful discovery. By design, Wi-Fi Direct is, therefore, mostly suited to consciously connect two or more devices at a specific point in time, and is not optimized for a continuous discovery process in the background.WFDS is a standard specification defined by the Wi-Fi alliance, which is built on current standard Wi-Fi direct.

WFDS components are:

- ASP: Device/Service discovery, Connection, Session management
- Send: File Transfer (UPnP/HTTP)
- Play: Media Streaming (UPnP/DLNA)
- Print: Printing services (IPP)
- Display: Screen Mirroring (Miracast based)
- Enable: Enabling other services

WFDS specification defines an architecture, protocols and functionality for interoperability of Wi-Fi Direct Services (WFDS). Application Service Platform (ASP) is a software service or library that implements the common functions needed by all applications and services conforming to the Wi-Fi Direct Services specification. ASP enables or creates a session which is a logical link between two ASP enabled peers to enabled streamlined and structured communication between them. The WFDS enabled system can have multiple ASP-sessions between two or more devices needing the WFDS functionalities. Wi-Fi Direct Services framework has defined components that interact to provide services capable Wi-Fi Direct devices.

ASP component is the logical entity to implement the common functions across all the services.

ASP Adaptation layer is an interface layer between the Service and ASP, which services should invoke to access the ASP Functionality. Fig. 2 shows the Overall Architecture.

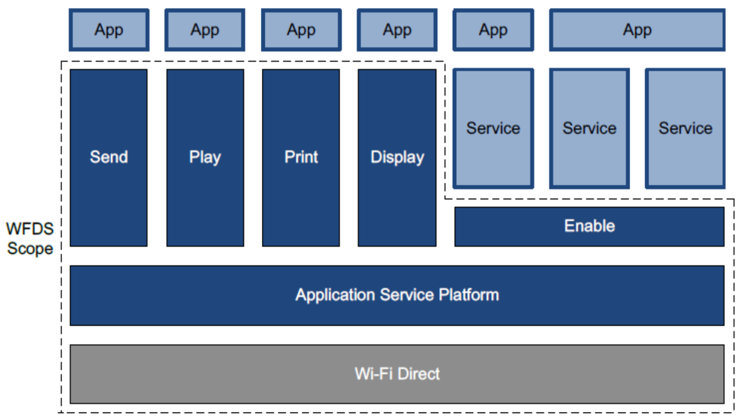

Fig 2. Overall Architecture

Although the general paradigm of Wi-Fi-Direct Service is to establish and maintain relationships as Peer Devices, there is typically a Service Advertiser and a Service Seeker role in setting up a connection. A Service Seeker is an application looking for an advertised service to connect to on a remote device. A Service Advertiser is an application that needs to make itself known to potential Service Seekers and expects incoming connection requests from interested Service Seekers. A single device may have multiple Service Advertisers and Service Seekers. Service Seeker side initiates the ASP-Session establishment. Service Advertiser side responds to an incoming request to establish ASP-Session. Service Advertiser shall advertise service(s).

Standard WFDS discovery process consists of advertising the Service and listening for the seek service request. Request is in the form of probe request containing first 6 octets of SHA 256 algorithm hash of service name. In the same way hash is calculated in advertising side, after hash matching advertiser responds in the form of probe response consisting of service name, advertisement Identity. Going further both the parties exchange more information about the service.

The message sequence flow for WFDS discovery process is shown in Fig. 3

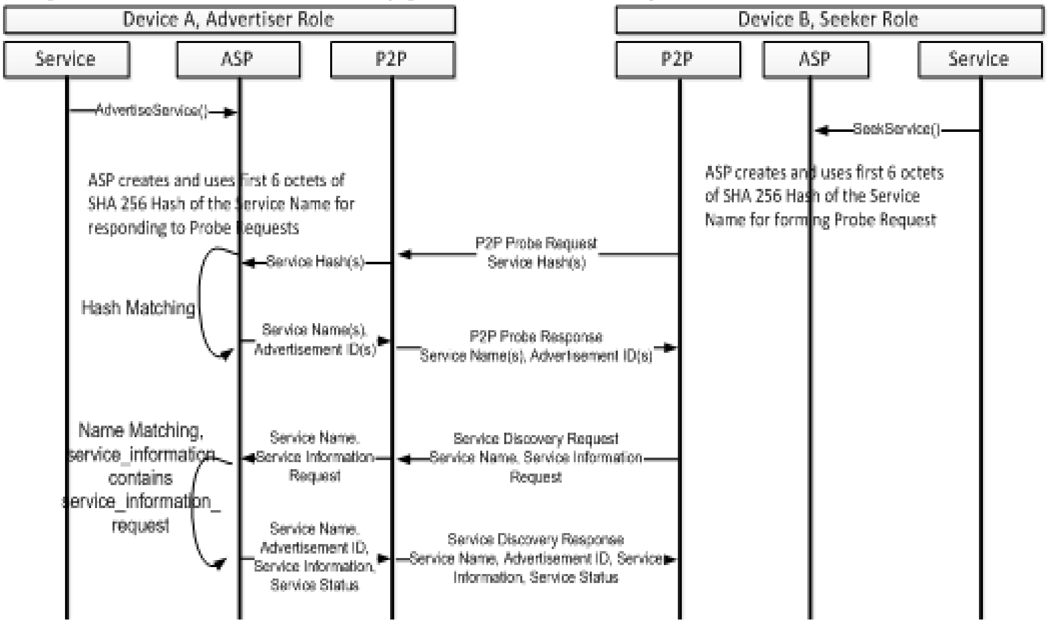

Fig. 3 WFDS Discovery Process

IV. IMPLEMENTATION

Consider the scenario shown in Fig 4. There are four devices A, B, C and D. The device A is playing the role of observer and the devices B, C and D are the advertisers. The devices A, C and D support both BTLE and WFDS while the device B supports only BTLE. The devices B, C and D are broadcasting their advertisements on the BTLE interface. The user of the device A wants to use one of the Wi-Fi Direct Services of either device C or D to accomplish his task but the device A is unaware of the services provided by the other three devices. With an effort to discover the services provided by devices B, C and D the device A starts listening to the advertisements being broadcasted by the other devices on its BTLE interface.

The device A needs to obtain two important pieces of information, apart from other information, from the advertising devices. These are:

- Does the advertising device support WFDS.
- If the advertising device supports WFDS then what are the services it provides.

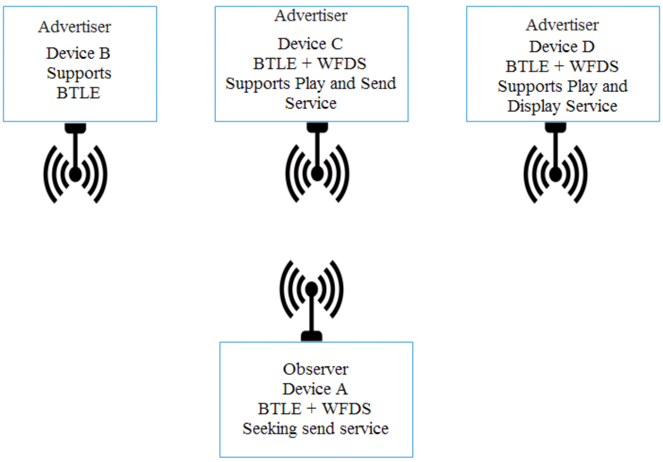

Fig 4. Use case scenario

Once the device A obtains this information it waits for an input from the user. The user browses the services provided by other devices and makes the following deductions:

- Device B does not support WFDS.
- Device C supports WFDS and the services it provides are, say, PLAY and SEND service.
- Device D supports WFDS and the services it provides are, say, PLAY and Display service.

Based on these deductions the user decides to use, say, SEND service provided by the Device C to transfer a file from his device (device A) to the Device C and so inputs his choice to the device A

This step triggers the second phase of the WFDS service discovery process which involves exchange of multiple messages .Then both devices, A and C, run through a sequences of procedures to successfully complete the file transfer.

In the above scenario if none of the devices supported WFDS then the user is provided with an option to either proceed using BTLE services or quit. The overall flow is depicted in the form of a flowchart in the Fig 5.

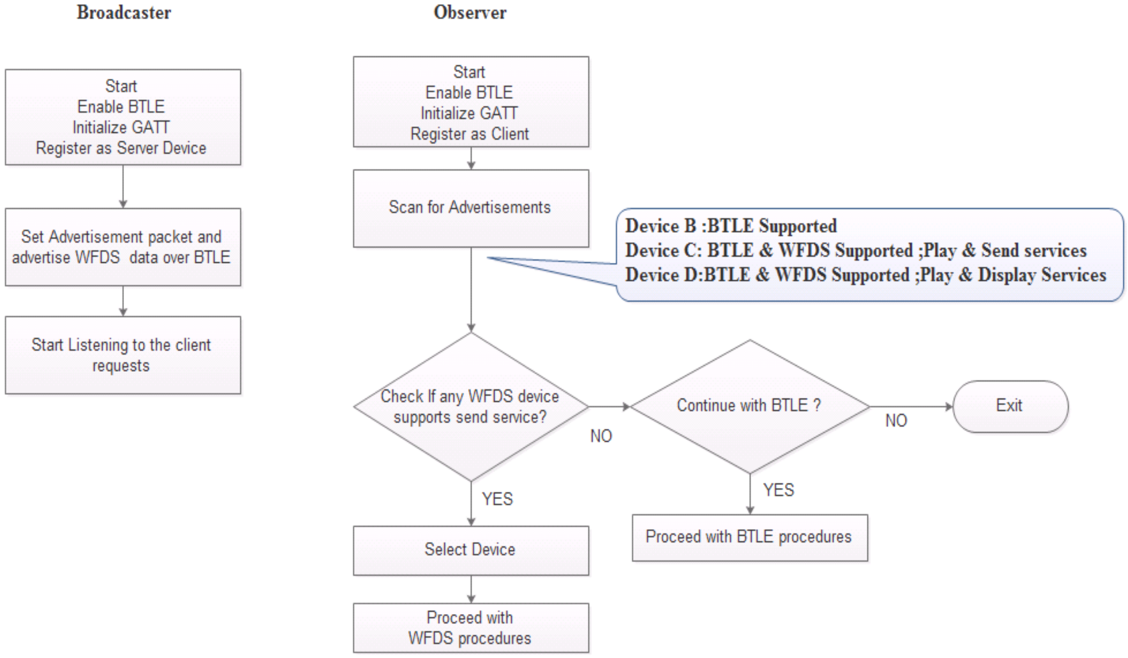

Fig 5.Flow Chart

An easy way to accomplish the idea is to identify the necessary parameters for WFDS connection and send them over the air in the form of BTLE advertisement packets as a part of first stage of WFDS discovery process. By looking at these advertisements a decision can be made to use WFDS or BTLE.

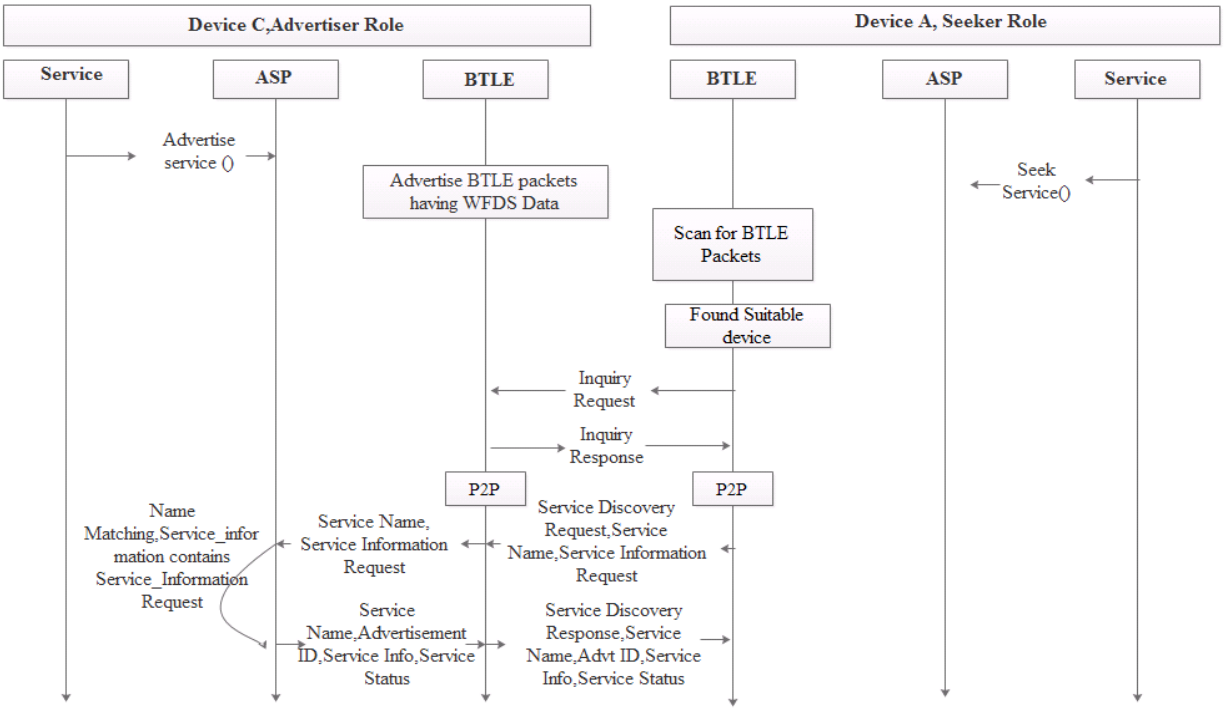

Fig 6. Implementation

Referring to Fig. 6 Device C advertising the service over the BTLE (as proposed) and the device looking for the service scans for the BTLE packets, when it finds the required service it triggers Inquiry request over BTLE interface by using the active scan method as it knows the advertising device. The Advertiser responds with an Inquiry Response. Then both the devices continue with customised WFDS discovery and in turn exchange service Discovery request and Service information request messages. So BTLE eliminates the redundant devices in early stage of discovery there by achieving considerable amount of power save. Compare Fig. 3 and Fig. 6, the proposed idea eliminates probe request and probe response which are costlier in terms of power requirement.

V. CONCLUSIONS

Energy-efficient operation is a key prerequisite for user acceptance of opportunistic device-to-device communication. Through this paper we brought forward a technology that enables communication at very low energy thereby making it a potential energy efficient communication standard for upcoming device-to-device scenarios. Its most widely implementable area is in internet of things for day to day user activities which demand low energy usage.

ACKNOWLEDGMENT

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REFERENCES

[1] Bluetooth Special Interest Group. Bluetooth v4.2 Specification
[2] Wi-Fi Direct Services Technical Specification Version 0.1.

