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# Bluetooth

## *Part 7: RFCOMM*

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UiB



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## Outline

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- RFCOMM definition
- RFCOMM devices and frame types
- Connecting and disconnecting
- Java RFCOMM API
- Introduction to device and service discovery

## RFCOMM Definition (1)

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- The name RFCOMM comes from a Radio Frequency (RF)-oriented emulation of the serial COM ports on a PC
- RFCOMM emulates full 9-pin RS-232 (EIA/TIA-232-E) serial communication over an L2CAP channel
- RFCOMM is based on a subset of the ETSI TS 07.10 standard for software emulation of the RS-232 hardware interface. TS 07.10 is used by GSM cellular phones to multiplex several streams of data onto one physical serial cable
- It can be used to connect to legacy applications

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## RFCOMM Definition (2)

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- RFCOMM provides multiple concurrent connections by relying on L2CAP to handle multiplexing over a single connection
- RFCOMM supports flow control on individual channels
- No error control, assumed that L2CAP provides an error free channel
- The *Serial Port Profile* (**SPP**) defines how an RFCOMM connection should be established between two devices

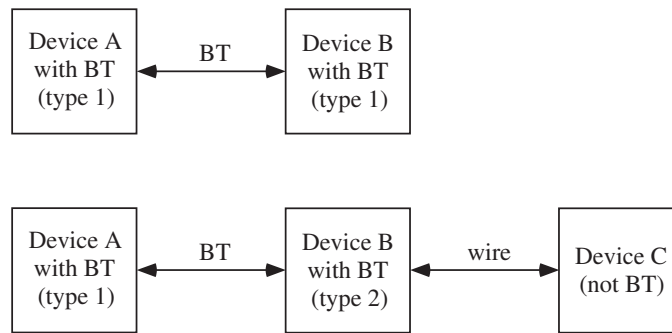
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- The Generic Access Profile (GAP) is the most basic Bluetooth profile. All other profiles, including SPP, are built upon GAP
  - the purpose of GAP is to make sure that all devices can successfully establish a baseband link
- Other profiles are built upon SPP: Dial Up Networking (DUN), FAX, Headset, Hands-free, SIM access, Generic object exchange

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- **Type 1**—Internal emulated serial port. An emulation entity is used to map a system specific communication interface (API) to the RFCOMM services, i.e., a type 1 device supports an application on top of RFCOMM
- **Type 2**—Intermediate device with physical serial port. A port proxy entity relays data from RFCOMM to an external RS-232 interface linked to another device

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**Figure 7-1** RFCOMM direct connect and RFCOMM used with legacy COMM device

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## RFCOMM Frames

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- RFCOMM is based on GSM TS 07.10 and use TS 07.10 frames to communicate
  - not all features of TS 07.10 are adapted by RFCOMM
- The RFCOMM frames become the data payload in L2CAP packets

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## RFCOMM Frame Types (1)

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- SABM—Set Asynchronous Balanced Mode (startup command)
- UA—Unnumbered Acknowledgement (response when connected)
- DISC—Disconnect (disconnect command)
- DM—Disconnected Mode (response to a command when disconnected)
- UIH—Unnumbered Information with Header check

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## RFCOMM Frame Types (2)

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- SABM, UA, DM, and DISC are control frames
- each RFCOMM channel has a Data Link Connection Identifier (DLCI). UIH frames on  $DLCI = 0$  are used for control messages, while UIH frames on  $DLCI \neq 0$  are used data

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## Connecting (1)

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- An L2CAP connection must be set up before an RCOMM connection can be set up
- RCOMM has a reserved Protocol and Service Multiplexer (PSM) value used by L2CAP to identify RCOMM traffic (PSM=0x0003)
  - the PSM is similar in function to the port number on an IP network
  - the PSM is used by a client to connect to a server

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## Connecting (2)

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- Connection procedure:
  1. Initiating device sends SABM (Set Asynchronous Balanced Mode) frame over L2CAP channel
  2. Responding device goes to Asynchronous Balanced Mode (ABM) and sends back an UA (Unnumbered Acknowledgement) frame
  3. Initiator sends a Parameter Negotiation (PN) command and responding device answers with a PN response frame

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- A device not willing to connect sends back a DM (Disconnected Mode) frame when it receives the initial SABM frame
- RFCOMM has a 60s timer which is started when a command is sent. If an acknowledgement isn't received when the timer elapses, the connection will be shut down
- if RFCOMM times out, it must send a DISC (Disconnect) command frame on the same DLCI as the original SABM frame

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**Java ME**

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## Why Use the RFCOMM API?

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- Communicating with a remote device using the RFCOMM API is similar to communicating over a socket connection, i.e., data is sent between devices via *streams*
- The RFCOMM API is simpler to use than the packet-oriented L2CAP API
- The API supports multiple Bluetooth connections over a single Bluetooth link
- Supports different levels of security (to be discussed in Part 10)

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## RFCOMM API

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- No new methods or classes are defined for the RFCOMM API. It utilizes existing classes and interfaces from the GCF (Generic Connection Framework) in CLDC
- All RFCOMM connections are initiated with `javax.microedition.io.Connector.open(String s)` where `s` is a valid URL of the form `{scheme}:{target}{params}`
  - `{scheme}` is the “btspp” protocol for both Slave and Master
  - `{target}` is the network address starting with “//”
  - `{params}` are formed as a series of equates of the form “;x=y”

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Parameters for RFCOMM Connection Strings

Name	Description	Values	Client or Server
master	this device must be the Master	true, false	both
authenticate	remote device must be authenticated	true, false	both
encrypt	link must be encrypted	true, false	both
authorize	all connections to this device must receive authorization	true, false	server
name	ServiceName attribute in service record	any valid string	server

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General Comments

- All parameters in the table are optional, i.e., they need not be included in the connection string
- All other parameter values will cause an `IllegalArgumentException` to be thrown by `Connector.open()`

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- Usually, the device initiating a connection, i.e. the client, becomes the Master
- Sometimes, a particular device is configured to be the Master because
  - it is required by a certain profile, or
  - the device must be able to form a piconet

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- The security parameters “authenticate,” “encrypt,” and “authorize” do not have to be set
- A security parameter that is not set has the value false unless another parameter requires this parameter to be true
  - if “encrypt=true” and “authenticate” is not part of the connection string, then “authenticate” is set to true because encryption requires authentication
  - “authenticate=false” and “authorize=true” is an invalid combination

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- For a **client connection**, the method `Connector.open()` returns a `StreamConnection` object (interface in `javax.microedition.io`)
- `Connector.open()` returns a `StreamConnectionNotifier` object for a **server connection** (interface in `javax.microedition.io`)
  - the `acceptAndOpen()` method must be called after `Connector.open()`
  - it blocks until a client connects to the server, then the method returns a `StreamConnection` object
- A client and a server communicate via `InputStreams` and `OutputStreams` returned by a `StreamConnection` object

See Java ME code examples `HelloClient` and `HelloServer` in Part 4

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- A `BluetoothConnectionException` is thrown if
  - an invalid combination of security parameters is passed to `Connector.open()`
  - an authentication, encryption, or authorization request fails during establishment of a connection
- Extends `java.io.IOException`

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## More on BluetoothConnectionException

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- When a server makes the request to `Connector.open()` to retrieve a notifier object, it can set “master=true” in the connection string to request that a client using this service is the Slave
- If the client device initiating a connection to the server device does not support a Master/Slave change, then an exception is thrown

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## Server Connections

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- The `{target}` for server connections is “//localhost” followed by a colon and the [Universally Unique Identifier \(UUID\)](#), 128-bit unsigned integer, for the service to add to the service record. See examples below
1. UUID is 0x102030405060708090A1B1C1D1E10073 and device can be either Master or Slave:

```
“btspp://localhost:102030405060708090A1B1C1D1E10073;  
name=Print_Server; master=false”
```

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## More Server Connection Strings

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2. All communication to the server must be authenticated and authorized:

```
"btspp://localhost:1231242432434A4AA3B056104AC0CD5F;  
authenticate=true; authorize=true; name=Echo"
```

3. The server must be the Master of the link and the link must be authenticated, encrypted, and authorized:

```
"btspp://localhost:AB9324854381231231231ADEFE49A02F;  
encrypt=true; authorize=true; master=true"
```

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## Server Connection Example (1)

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```
// Create a notifier object  
StreamConnectionNotifier notifier = (StreamConnectionNotifier)  
    Connector.open("btspp://localhost:123456789ABCDE;name=Echo_Server");  
  
// Create I/O streams  
StreamConnection conn = notifier.acceptAndOpen(); // Blocks!  
OutputStream output = conn.openOutputStream();  
InputStream input = conn.openInputStream();
```

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## Server Connection Example (2)

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```
⋮  
// Close the streams and the connection  
output.close()  
input.close()  
conn.close()
```

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## How to Generate UUIDs

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- The Linux `uuidgen -t` command generates a 128-bit UUID based on
  - 80 bits obtained from the current system time
  - 48-bit hardware address of NIC
- The command will generate UUIDS on the form `feb7b8d9-c9a0-11d8-a536-000a95a4ddae`
- The hypens “-” must be deleted before the UUID can be used by JSR-82

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- `{scheme}` is still given by the “btspp” protocol
- `{target}` starts with “//” followed by the [Bluetooth address](#) of the server device and the [server channel identifier](#)
  - The server channel identifier is a number between 0 and 31 assigned by the JSR-82 implementation. The number is similar to a TCP port and identifies a service on a device
- `{params}` are “master,” “authenticate,” and “encrypt”

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## Examples of Client Connection Strings

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1. Valid client connection string that connects to a Server device with Bluetooth address 008003DD8901, using server channel identifier 1:

```
“btspp://008003DD8901:1;authenticate=true”
```

2. String requiring that the local device is the Master and using server channel identifier 5:

```
“btspp://008012973FAE:5;master=true;encrypt=true”
```

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## More on Client Connections

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- When the connection string is passed to `Connector.open()`, an attempt is made to establish a connection to the server device
  - unlike for a server connection, this connection is established once `Connector.open()` returns

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## Client Connection Example (1)

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```
String connString = "btspp://008012973FAE:5;master=true";

// Establish a connection to the server
StreamConnection conn = (StreamConnection)
    Connector.open(connString);

// Create I/O streams
InputStream input = conn.openInputStream();
OutputStream output = conn.openOutputStream();
    :
```

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## Client Connection Example (2)

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```
    :  
    // Close the streams and the connection  
    input.close()  
    output.close()  
    conn.close()
```

**Next:** The remainder of this lecture discusses classes used by a *client* to carry out a *combined* device and service discovery (first discussed in Part 4). It is also shown how to set some security parameters. We will return to these topics in later lectures

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## javax.bluetooth.LocalDevice

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- The `javax.bluetooth.LocalDevice` class defines the basic functions of the Bluetooth manager
- The Bluetooth manager provides access to and control of the local Bluetooth device

```
1 LocalDevice local = LocalDevice.getLocalDevice();
```

- Note that there is no public constructor, multiple calls to `getLocalDevice()` will return the same object

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- The `javax.bluetooth.DiscoveryAgent` class provides methods to perform device and service discovery
- A local device must have only one `DiscoveryAgent` object

```
2 DiscoveryAgent agent = local.getDiscoveryAgent();
```

- Observe that the `DiscoveryAgent` must be retrieved by a call to `LocalDevice.getDiscoveryAgent()`

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## DiscoveryAgent.selectService()

- Attempts to locate a service that contains `uuid` in the `Service-CLASSIDList` of its service record

```
String selectService(UUID uuid, int security, boolean master)  
throws BluetoothStateException
```

- The method returns a string that may be used in `Connector.open()` to establish a connection to the service
- The `ServiceRecord` interface and the `javax.bluetooth.UUID` class may be used to specify the `selectService()` parameters

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The `ServiceRecord` interface describes characteristics of a Bluetooth service. The following constants are defined:

`static int AUTHENTICATE_ENCRYPT` Authentication and encryption are required for connections to this service

`static int AUTHENTICATE_NOENCRYPT` Authentication is required for connections to this service, but not encryption

`static int NOAUTHENTICATE_NOENCRYPT` Authentication and encryption are not needed on a connection to this service

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- The `UUID` class defines *universally unique identifiers*. These 128-bit unsigned integers are guaranteed to be unique across all time and space
- Constructor `UUID(String uuidValue, boolean shortUUID)` creates a `UUID` object from the string provided
  - If `shortUUID` is true, `uuidValue` represents a 16-bit or 32-bit `UUID`

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- RFCOMM provides serial port emulation for legacy applications and Bluetooth profiles
- RFCOMM supports end devices with applications on top and intermediate devices with physical RS-232 serial ports on top
- RFCOMM utilizes an L2CAP connection
- RFCOMM frames are sent in the payload field of L2CAP packets

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- The JSR-82 API for RFCOMM is the most used API within JSR-82 because
  - RFCOMM provides serial two-way communication
  - the API reuses familiar APIs from Java ME
- To make it easier to start writing MIDlets, we presented a simple technique for carrying out a *combined* device and service discovery

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