

Is Bluetooth Broadcasting Practical and Useful?

Alf Inge Wang and Johan Ho
Dept. of Computer and Information Science
Norwegian University of Science and Technology
N-7491 Trondheim, Norway
alfw@idi.ntnu.no / ho@idi.ntnu.no

ABSTRACT

Bluetooth (BT) has become a standard for personal area networks connecting mobile devices including mobile phones, PDAs, laptop computers, headsets, keyboards and other devices. The most usual usage of BT networks is to connect one device to another device. However, the BT technology can also be used in other ways. This paper describes experiences from developing and exploring a BT broadcasting system with the focus on investigating the usefulness and practical issues related to BT broadcasting. In particular, the paper looks at what kind of application areas BT broadcasting can be used for and how privacy can be established in such environments. We also consider some collaborative services that can be provided through BT broadcasting.

KEYWORDS: Mobile and Wireless Computing, Bluetooth broadcasting, Bluecasting, Bluespam, User privacy.

1. INTRODUCTION

In the recent years, most people have become surrounded by a variety of consumer electronic devices. Many homes are now equipped with laptop computers, mobile phones, PDAs, printers, digital video, and photo cameras. Even though all these devices work well on their own, there are always situations where it is useful for one device to interchange data with another. This is where Bluetooth comes into the picture.

Bluetooth (BT) is a low power and relatively high bandwidth wireless technology [9] for connecting various electronic devices. The BT technology makes it possible to establish personal area networks (PANs) between devices without much effort spent on configuration and setting up the network. The range of such networks is typically from a few meters up to 100 meters depending on the BT capabilities of the devices used. Although, the BT technology is normally used to exchange data between two devices, it can also be used for other purposes. [6, 8] describe how BT

can be used to provide Internet gateways for BT enabled devices such as PDAs, laptop PCs and mobile phones. Further, BT can be used in mobile payment systems [15], to stream video and audio to BT devices [2], and even provide dating services and network games [13].

Lately, several prototypes and products to provide BT broadcasting (bluecasting) have appeared. Such systems typically consist of a BT server that broadcasts data to nearby devices. The most common usage of bluecasting is currently in promotion of products by broadcasting content to nearby BT enabled mobile phones. This kind of broadcasting can also be called proximity-based broadcasting or simply bluecasting. One example on how bluecasting has been used is the company Filter UK that placed bluecasting servers in the vicinity of a billboard at a railway station. The billboard informed that if you BT enabled your mobile phone, you could receive music, pictures and information about a rock band [4]. Bluecasting provides a new way of offering information and data.

This paper investigates for what purposes bluecasting can be used and the problems related to bluecasting. Further, we describe some practical solutions to the problems. The discussions and solutions described in this paper are based on experiences from developing and using our own bluecasting system Baloo. Our investigation can be summarised into four research questions:

- RQ1: Is BT suited for broadcasting,
- RQ2: What kind of information can be broadcasted using BT,
- RQ3: Can bluecasting be provided in a way that not compromise users' privacy, and
- RQ4: What usage area(s) is bluecasting best suited for?

The answers to these research questions have been found through a combination of studying other systems, implementing our own system and exploring usage of bluecasting in general.

The rest of the paper is organised as follows. Section 2 describes the bluecasting system Baloo. Section 3 describes and discusses various issues related to bluecasting that forms a foundation to answer the research questions. Section 4 describes related work in this area, and finally Section 5 summarises our findings and give answers to the research questions.

2. THE BALOO BLUECASTING SERVER

Even though there are several bluecast systems available, we wanted to develop our own system to fully explore the possibilities in bluecasting. The goal of our bluecasting server, Baloo, was to provide a flexible server that could broadcast any type of information to any BT device. Figure 1 shows the four layered architecture for Baloo.

The first layer in Figure 1, the *Web content layer*, makes it possible to generate dynamic content on web that can be broadcasted using Baloo. This layer can be used to combine various information on the web with local context information such as time, date, location, and weather – enabling context sensitive information.

The second layer, the *Resource layer*, is responsible for managing the resources that are broadcasted in the system. The current Baloo implementation supports two types of resources: Files and web content. The web content can be dynamically be generated using the layer below, or can be any web-page fetched from the Internet. Any file type can be broadcasted, but not all file types are supported by the receiving wireless devices.

The third layer, the *Configuration layer*, takes care of the configuration the broadcast service. This layer makes it possible for the user to ask for specific services from the broadcast server. This is supported by mapping *user commands*, which can be sent to Baloo, with resources. E.g. can a user command "cnn" be mapped to the content of the web-page www.cnn.com. This layer also provides services for collecting and generating statistics of how the Baloo server is used.

The fourth layer, the *Communication layer* is responsible for all the communication between the Baloo server and the nearby wireless devices. The communication protocol used is based on the request-response paradigm. Currently, the Baloo implementation only supports BT wireless networks. The Baloo server has been implemented using C# and Microsoft .NET framework. The 32feet.NET library was used to manage the BT connectivity. The Baloo server requires a PC running Microsoft Windows XP service pack 2 operating system and the .NET framework version 2.0 installed. In addition, a BT device (hardware) compatible with Microsoft's BT stack must be installed. A screenshot of the Baloo server running is shown in Figure 2.

The functionality provided through the Baloo user interface is divided into three main areas:

- **Main configuration:** In this tab, all the configuration of the server is carried out.
- **Manage broadcast items:** In this tab, new resources that can be made available for BT devices connected to the server are managed (as shown in Figure 2). All the resources provided in the server can be activated by the BT device using a unique command (more on this in the following section).
- **Statistics:** Provide an overview of how the various resources provided in the server are used by the users.

3. BLUECASTING EXPERIENCES

This section investigates several issues related to bluecasting.

3.1. Bluespam

Bluespam is a potential problem related to bluecasting. This problem can be illustrated through a small scenario:

A group of friends is sitting in a café in a shopping centre. Two in the group decide to exchange a funny picture using the BT functionality on their mobile phones. To be able to receive the picture, the receiver enables his mobile phone to be "BT discoverable". When this is done, this person starts to receive a dozen bluecasting advertisements, but not the picture he really wants from his friend.

This scenario describes a very important problem with BT broadcasting. If mobile users start to get bluecasts they really do not want, bluecasting will be only seen as a new spam infested communication channel (bluespam). The problem is actually worse than for email spam. Even if email spam is annoying, the real emails will usually come through. For the situation described above, bluespam can actually block all other BT communication - devaluating the usefulness and flexibility of BT.

We have explored ways to avoid this problem, and identified some approaches that can be used to avoid bluespam:

- **Disable discoverable BT setting:** A very simple solution to the problem described above is to not let the mobile phone be BT discoverable. This will disable the mobile phone to receive any bluecasts. However, the only way the friends can transfer the picture between the mobile phones in this mode is if they have stored each other's BT IDs in beforehand. If this is not the case, the only way to solve the problem is to an area out of reach of bluecasting servers to transfer the picture.

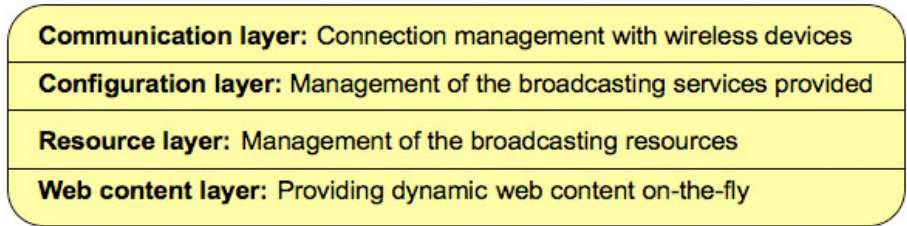


Figure 1. The Baloo Bluecasting Server Architecture

- Require bluecast clients:** Another approach to this problem is to require the users of the bluecast service to install a bluecast client before any bluecasts can be received. This can be a useful approach in many ways, as a bluecast client also can offer a multimedia player for showing the bluecasts. However, this approach requires that the users first download and install the bluecast client before they can receive any bluecasts. Such clients can be implemented in Java 2 Micro Edition (J2ME), making it easy to deploy to various devices. For some users, to install a bluecast client would be a technical challenge and therefore be dropped. This approach also demands that the user starts the bluecast client before he can receive any broadcasts. Such clients are not likely to be run in background because it would slow down the device and consume too much computing and battery power. Thus the number of clients reached using this approach will be drastically reduced.
- Broadcast only to registered devices:** A way of avoiding bluespam is to only broadcast to mobile devices that have registered for this service. Such a registration can be carried out on a web-page or also directly from the mobile phone through a WAP page. This solution also carries the same problem as the solution above that some user would find this a technical challenge. This approach would also require that the mobile user will have to give his BT ID to a third party that can be a potential threat to user privacy. For some users this will not be a problem, but for others it would be out of the question to give away their BT ID.
- Broadcast only as a response to text messages:** This approach requires the user to take the initiative to receive bluecasts by sending a text message to the bluecast server. This is very similar to sending a SMS, but the message must be sent via BT directly to the bluecast server. This option also gives opportunities to provide different types of services depending on the text in the message. E.g., the user can write names on products she is interested in, or name of the service she wants. This approach must ensure that the users are in-

terested in getting the bluecast as the users must take the initiative. One advantage using this approach, is that the user is more likely to be interested as the user takes the initiative and the user can choose e.g., to get more information about a particular product or activate a particular service.

Figure 3 shows how a message can be sent to a bluecast server on a mobile phone (Nokia 3650). First, the user writes the text in a message (a), then sends the message using BT (b), and finally selects the bluecast server ID (c). The implementation of the Baloo bluecast server supports the latter approach enabling any BT user to receive broadcasts from Baloo without any installation. The main reason for choosing this approach for bluecasting was to be able to provide more advanced services and open for collaborative services. Collaborative services can be provided by services where Baloo users can share and communicate by managing input from one user that can be provided for another user later on. However, this approach requires the user to spend 3-5 seconds to write a small message to be sent to bluecast server to get a response. An advantage with this approach is as long as the clients have the ID of the bluecast server it takes only a couple of seconds to receive a bluecast.

3.2. Logging of User IDs and Activities

Most of the commercial bluecast systems available provide logging statistics of how many users that have received bluecasts. Such logging services can be used to look at what times the services are most popular, what broadcasts are most popular, etc. Depending on the user information being stored, this could potentially be a user privacy problem. Any type of bluecast server must access the BT ID of the devices receiving the broadcasts. For active bluecast systems, the server will collect all BT IDs to the surrounding devices that have been set to be BT discoverable. For such systems, it is necessary to store the BT IDs for some time to avoid sending the same broadcast to the same device several times. For passive bluecast systems, where the clients will request the server to receive a bluecast, this is not necessary. To produce statistics for bluecast services, only counters for the different services are needed. How-

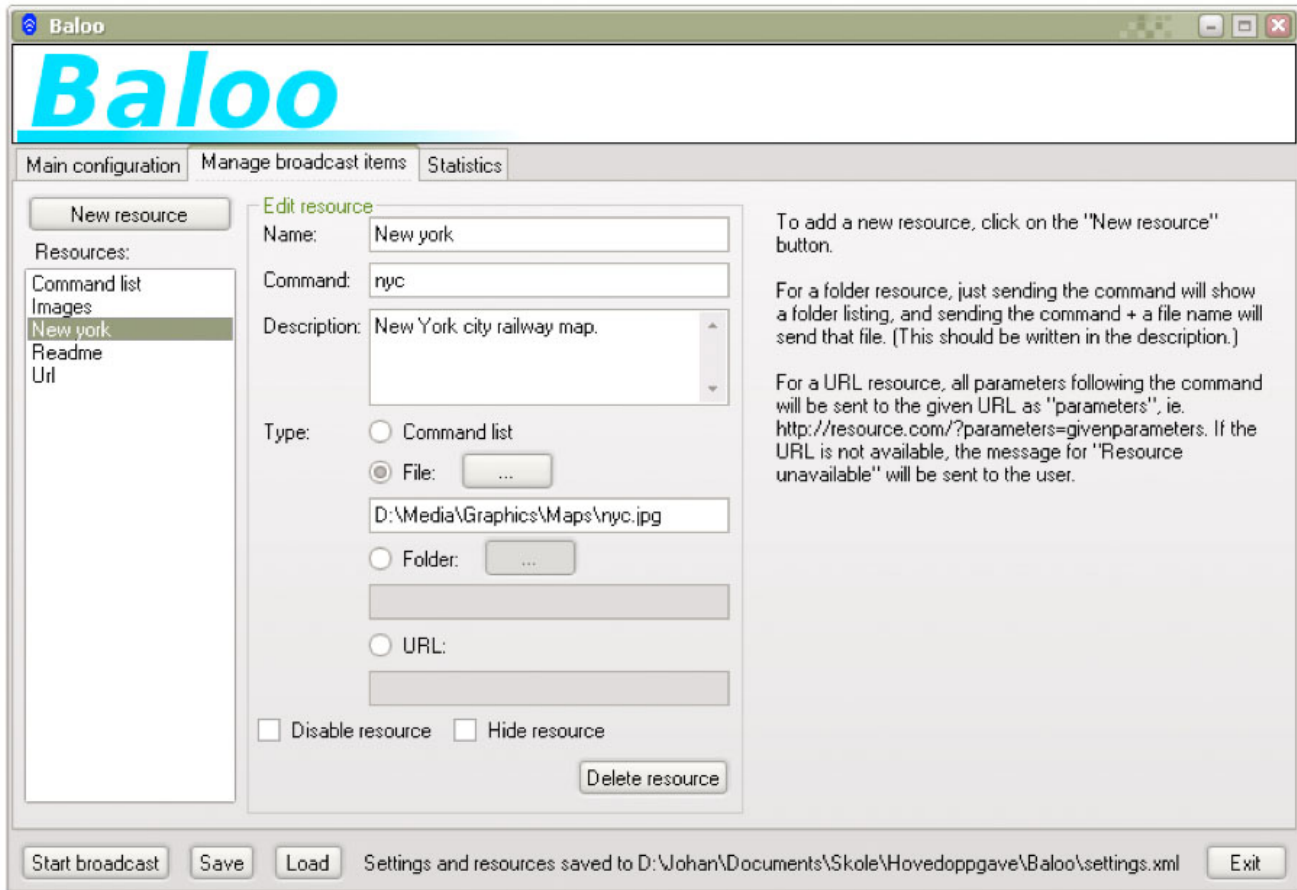


Figure 2. Configuring the Baloo Server

ever, if there is a need to count if the same device has been visiting the same bluecast server several times, the server need to store the BT IDs. This raises the question about for how long should this information be stored? To address this problem, one solution would be to store an encrypted version of the BT ID instead of the ID itself. By using this solution, it will be harder to relate the BT ID directly to the device. In addition, the stored encrypted BT IDs (hash) can be deleted at the end of a day, after the number of unique visits has been calculated.

Logging in the Baloo bluecast server is implemented using the encrypted BT ID approach. By doing so, the server can maintain a full overview of the usage of various services provided by the server without compromising the users privacy.

3.3. What File Types can be broadcasted?

Through usage of the Baloo bluecast server, we wanted to explore the different file formats that can be used for blue-casting and their usefulness in a bluecast service. In our

tests, we investigated how four different types of mobile devices handled broadcast of various file types. The four different types of devices we looked at were mobile phones running Symbian OS (e.g. Nokia and Sony Ericsson), Palm OS PDAs, Windows Mobile PDAs and Windows XP laptop computers. The file types that are usually supported in commercial bluecasting systems are text files, images, animations, audio, video, Java applications, vCard (business card files) and vCal (calendar event files). The tests we performed showed that the limitation of file formats are restricted only by the capabilities of the receiving devices. The tests also showed that the different types of mobile devices handled receiving files in different ways.

A Symbian OS mobile phone can receive any file type into the inbox, but few file types apart from text, calendar-information, pictures, audio and video can be shown on the device. If an unsupported file is received, this file can be transferred to a computer that has the software to support the file format. For file types that are supported by the OS, the user can launch the application by opening the file in the inbox directly.

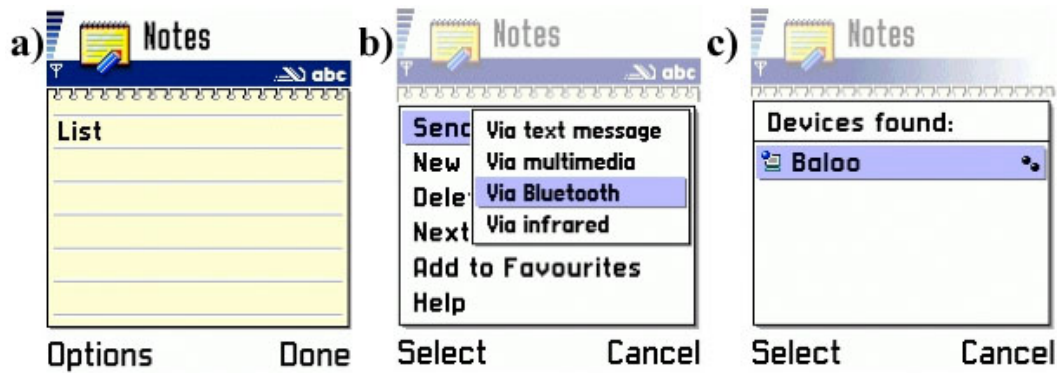


Figure 3. Sending a Message to Bluecast Server

A Palm OS PDA does not accept to receive other files types than the ones supported by installed applications. However, when supported files are received by the device, a suitable application will automatically be launched. A PDA can typically handle much more file types than a mobile phone, which includes typical office file types, various text formats and a broader support for audio and video formats. However, what types of files that can be received is dependent on how many types of applications the user has installed on his device.

Windows Mobile PDAs and Windows XP laptop computers works similarly when it comes to receiving files using BT. All file types are received and the files will be stored in somewhere in the file system. This can be a bit confusing on a PDA, where it is more cumbersome to navigate in the file system. This means that the usability of a bluecast service is very low for Windows Mobile PDAs and Windows XP laptop computers as the user must find the broadcasted files themselves and launch a program to show or use the files. The problem is less confusing on a Windows XP laptop, where the user usually get a notification window that will tell the user where the received files have been stored.

A possible solution to improve the usability of the mobile Windows devices could be to provide a bluecast client that receive files and automatically launches appropriate applications. Generally, Windows PDAs and laptops supports a wide variety of file types depending on installed applications.

3.4. Bluecast Services

Unlike other digital channels for sending information, bluecast allows for directing broadcasted information towards people in a limited area, rather than a group of known people. Compared to digital services like SMS, MMS and e-mail, the most noticeable difference is that these services requires known recipients. Bluecast is thus useful for spreading information for unknown or temporary recipients. The

most well know usage of bluecasting is to promote products by broadcasting information, audio or video related to this product. However, bluecasting can be used for other purposes as well.

- **Bluecast contact information:** Bluecasting can be used to broadcast contact information to mobile devices. In this way, the mobile user would receive useful information in very handy way. Such usage of bluecasting is useful e.g. for museums, public offices, shops etc.
- **Bluecast portable information:** In some situations, you would like to have more information about e.g., an attraction, a concert, a shopping centre, and a museum where you are. In such scenarios, the mobile device is used as a portable information carrier, and the bluecast service provides information related to the location you are. Such information can be public transportation schedules, monument descriptions, shopping centre inventories, etc.
- **Bluecast before an event:** In relation to events like concerts, sports arrangements, guest lectures, a bluecast server can be used to broadcast a calendar event that will automatically be placed in you digital calendar on you mobile device. Such a calendar event usually includes time, date, and can also provide an alarm before the event starts and information about the location.
- **Bluecast during an event:** Bluecast can also be used to broadcast material related to an on-going event. Some examples could be to broadcast the slides during a lecture, broadcast a MP3-file during concert, or broadcast contact information during a paper presentation on a conference.
- **Bluecast user services:** A bluecast server can be set up to provide bluecast zones for mobile users to e.g.

fetch useful information from the web, send messages to friends, or provide user contests (like photo contests etc.). Such services can be used to support collaboration between mobile users. One example is that the bluecast server can route information from one user to another using its the internet connection. Another example is for the bluecast server to provide a notice board, where users can share important notices (provided by the users themselves). Also the notice board can allow one user to add a notice for a specific user. When the target user walks by the bluecast server, he will be notified about the notice from the other user. In this way, the bluecast server can work as an electronic notice board. Such notices are most useful, when the notices are relevant to the surroundings of the bluecast server (context sensitive information).

The list above is only a few examples of areas where bluecasting can be used. All these examples are supported in Baloo.

3.5. BT Limitations in Bluecasting

The main advantage by using BT for broadcasting is that sending information using BT is cost free for the provider (unlike SMS-services). Further, it does not require expensive infrastructure to provide a bluecast server. For simple services, a portable PC with a BT adapter is sufficient. For a service that can serve more people simultaneously, several bluecast servers can be used. Another advantage is that the broadcasts can be more directed to products by placing the bluecasts in direct relation to the product location or another promotion of the product.

When considering the technical details of BT, it is obvious that BT was not built for supporting broadcast intentionally. One BT unit can only send data to maximum seven other BT units simultaneously. To avoid this problem, it is possible to install several bluecast servers in the same location. However, it is of no use to install too many bluecast servers, as all these servers use the same radio frequency spectrum in the 2.45 GHz band. To avoid interference with other devices, the BT protocol divides this band into 79 channels that are 1 MHz wide. A BT transmission changes between these channels up to 1600 times per second. In practice it is not recommended to install more than 3 bluecast servers in the same area that can maximum serve 21 simultaneous BT devices.

Another major problem is the long discovery time related to establish BT connection between devices. For BT version 1.x, it can take up to 20 seconds before the devices have been discovered and connection has been established. Depending on the range of the bluecast station, the bluecast server may not be able to connect to devices of passing people before they are out of reach. For more recent BT devices

(BT version 2.x) the discovery time in practical usage can be the half, minimising this problem.

Finally, the relative low transfer speed in BT is also a problem. The maximum transfer speed in BT is 723.1 Kbits/s in version 1.x and 2.1 Mbits/s in version 2.0 [14] (most recent mobile phones now support BT version 2.x). In practice, the transfer speed for most BT devices is between 5KBytes/s and 40KBytes/s. This means that the files sent to the users should be kept relatively small. This is also the case for multimedia files (music files, video files). Again, this means that the content must either be very short or have a relatively low quality.

4. RELATED WORK

Bluecasting as a phenomena has not been described or investigated in the research literature. However, there are some papers that describe related issues. [6, 8] describe approaches for providing an Internet gateway using BT. Our own bluecast server Baloo can also be used to broadcast web-content directly to BT devices. However, Baloo does not give the opportunity to surf directly on the web.

In [5], an approach for using wireless broadcasting to form the infrastructure for handling data between sensors and mobile devices is described. BT is mentioned as on possible wireless network technology that can be used. This approach is very similar to bluecasting, but the data broadcasted is meant as input to applications on the mobile devices and not files that are directly relevant for the receivers. There are several commercial products and projects that provide bluecasting. The most well-know product is called BlueCasting [12] and is developed by Filter UK. This system uses small BT station boxes that can be placed in relation to advertisement posters, billboards or similar. The BT stations can broadcast various file types to any passing person with a mobile phone.

Jellingspot [7] from Midletsoft uses another approach. Jellingspot requires the users to install a Java-based client on the mobile devices to receive the broadcasts. They avoid the problem with bluespam, but require all users of the system to install client software. Even though they provide support for many models of mobile phones, some users will be left out, as there does not exist client software for their mobile phone model. The main problem for approaches like Jellingspot is the amount of new released models for mobile devices every month.

Peekablue [10] is a broadcast server that can be run on mobile phones. This software can be used to share pictures among friends or to anyone. Peekablue is currently available for 17 mobile phone models.

There are also other bluecasting projects going on like Alterwave [1], BlueBlitz [3] and BroadTooth [11] that provide the similar functionality to the ones above. BlueBlitz also

provides support for two-way communication between the broadcasting unit and the mobile unit.

5. CONCLUSION

In this section, we will summarise our findings related to bluecasting and answer the four research questions:

- **RQ1: Is BT suited for broadcasting?**

If we consider the technical aspects of BT, it is obvious that the technology was not created for broadcasting intentionally. The transfer speed of BT is relatively low when several devices receive data simultaneously. In addition, the limited bandwidth shared by all BT devices limits the number of simultaneous recipients for BT broadcasts, even if more bluecast servers are installed. Another problem is the long discovery time to establish connection between BT devices. This limits the broadcasts to be sent to relatively stationary mobile devices. All in all, BT is not the optional technology for broadcasting and put strong limitations on the number of recipients, and the size of the files broadcasted. However, the new versions of Bluetooth limit this problem by higher transfer speed and lower discovery time.

- **RQ2: What kind of information can be broadcasted using BT?**

The BT technology itself does not put any restriction on what type of data that can be sent. The main challenge is the abilities of the receiving devices to display and use the data. We found that Palm OS based PDAs and Symbian OS mobile phones handles bluecasts in a user-friendly way that automatically displays the data when received. However, Mobile Window PDAs will only store the files in the local file system, and it is up to the user to view data. One solution to this problem is to provide a bluecast client like Jellingspot do [7]. In general, most mobile devices can receive file types like text, vCal, vCards, and the most well known picture, audio and video formats.

- **RQ3: Can bluecasting be provided in a way that not compromise users' privacy?**

There are three ways of solving this problem. One way is for the recipients to register before they will receive any broadcasts. This means that the bluecast provider would have to store the recipients BT IDs. Another solution is to demand that the receiver installs a bluecast client on his mobile device. Finally, the users can initiate the broadcast themselves by sending text messages to the broadcast server (the approach used in Baloo). The main advantage with the latter approach is that it does not require to install any client software and it

makes it possible to provide various services from the same bluecast server.

- **RQ4: What usage area(s) is bluecasting best suited for?**

Usage areas of bluecasting can be summarised into three main areas: File sharing (e.g., sharing public documents in a office area), Sending compact information (e.g., contact information for a public office), and Send information to large groups (e.g. in relation to special events, special locations etc.). Generally, the usage areas of BT is only limited by the technical limitations of BT. This means that bluecasting is best suited for broadcasts for relatively few people simultaneously (less than 20), within a limited area (within a radius of 20-100 meters), for relatively stationary recipients, and for broadcasting small files. In addition, bluecasting can be used for collaborative purposes, by providing BT servers where users can share information.

As shown in this paper, there are a few challenges to overcome for using BT for broadcasting within areas like transfer speed and connection time, user privacy and usability. The technical challenges are likely to be solved in near future by new BT devices supporting faster and more connection efficient BT networks. The user privacy issue is easy to solve using encryption of user BT IDs like we used in Baloo. The main challenge here is for the users to trust the bluecasting providers that their BT IDs will not be stored on the bluecast server. Concerning usability, BT is today one of the PAN technologies that is easiest to configure and set up. The main challenge here is to provide sufficient support in the operating systems on the mobile devices to further improve the usability of BT.

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