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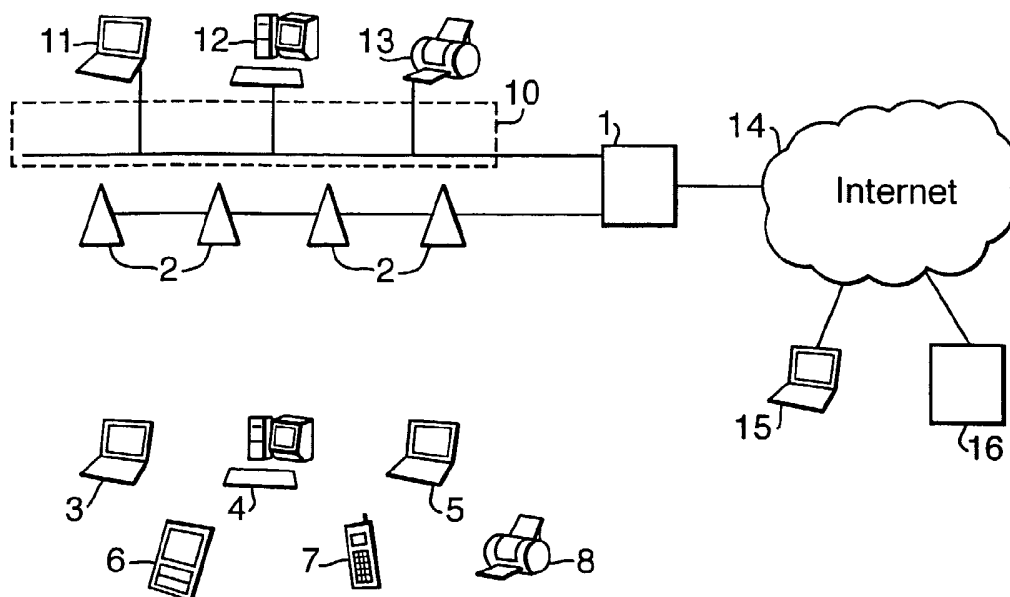
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(54) Title: HANDOFF OF WIRELESS CONNECTIONS



(57) Abstract: According to the invention, a method is provided in which a wireless communications device (an end point) in wireless network in a connection with a first network Access Point is handed off to a second network Access Point. The second Access Point receives scheduling information about the end point from the first Access Point prior to the establishment of the connection between the second Access Point and the end point. The timing information facilitates the efficient establishment of a connection between the second Access Point and the end point.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

HANDOFF OF WIRELESS CONNECTIONS

Background to the Invention

Wireless types of networks are now becoming more wide spread. Wireless
5 communication can be broken down into one of three main categories, radio, cellular
and local. Radio communications are used for mainly long distance work, and cellular
communications are used for mobile phones and the like. At present, the cellular
system can also be used to provide limited Internet access using WAP (Wireless
Application Protocol) phones. Internet access is also possible via a cellular phone, a
10 GSM modem and a PC/PDA.

In addition to this, the local communication standards are also provided for
short-range radio communication. These systems have been used within the
production of wireless networks.

One such short-range radio communication radio system is Bluetooth which
15 can be used to provide customer premises wireless links for voice, data and multi-
media applications.

A Bluetooth Radio Frequency (RF) system is a Fast Frequency Hopping
Spread Spectrum (FFHSS) system in which packets are transmitted in regular time
slots on frequencies defined by a pseudo random sequence. A Frequency Hopping
20 system provides Bluetooth with resilience against interference. Interference may come
from a variety of sources including microwave ovens and other communication
systems operating in this unlicensed radio band which can be used freely around the
world. The system uses 1MHz frequency hopping steps to switch among 79
frequencies in the 2.4GHz Industrial, Scientific and Medical (ISM) band at 1600 hops
25 per second with each channel using a different hopping sequence.

The Bluetooth baseband architecture includes a Radio Frequency transceiver
(RF), a Link Controller (LC) and a Link Manager (LM) implementing the Link Manager
Protocol (LMP).

Bluetooth version 1.1 supports asymmetric data rates of up to 721Kbits per
30 second and 57.6Kbits per second and symmetric data rates of up to 432.5Kbits per
second. Data transfers may be over synchronous connections, Bluetooth supports
up to three pairs of symmetric synchronous voice channels of 64Kbits per second
each.

Bluetooth connections operate in something called a piconet in which several nodes accessing the same channel via a common hopping sequence are connected in a point to multi-point network. The central node of a piconet is called a master that has up to seven active slaves connected to it in a star topology. The bandwidth
5 available within a single piconet is limited by the master, which schedules time to communicate with its various slaves. In addition to the active slaves, devices can be connected to the master in a low power state known as park mode, these parked slaves cannot be active on the channel but remain synchronised to the master and addressable. Having some devices connected in park mode allows more than seven
10 slaves be attached to a master concurrently. The parked slaves access the channel by becoming active slaves, this is regulated by the master.

Multiple piconets with overlapping coverage may co-operate to form a scatternet in which some devices participate in more that one piconet on a time division multiplex basis. These and any other piconets are not time or frequency
15 synchronised, each piconet maintains its own independent master clock and hopping sequence.

The Bluetooth specification has therefore been designed for the primary purpose of allowing electronic devices to communicate with each other. Thus, the system is typically utilized in an environment in which one-to-one communication is
20 achieved between two Bluetooth enabled devices.

In the situation in which voice communication is being provided, this will typically be achieved either using a handset, a Bluetooth enabled phone, or a voice communication enabled Bluetooth PDA (otherwise known as an End-Point). The user will utilize the Bluetooth device as a handset in the normal way. Signals are then
25 transferred via a Bluetooth link to some form of connection to a network. Thus for example, this may be achieved by establishing a Bluetooth link with a desktop PC, or the like. Voice data received from the Bluetooth enable communications device will then be transferred from the PC to a local area network and then on either to a PBX (private branch exchange), the Internet (for voice over IP (VOIP)), or the PSTN (public
30 switched telephone network).

However, the Bluetooth system is only capable of communicating over short distances. In addition to this, the Bluetooth specification does not include any protocol regarding the transfer of voice calls from one Bluetooth device to another. As a result, if the user's Bluetooth enabled communications device is moved out of range of the

desktop PC then Bluetooth connection between the communications device and the PC will be lost. As a result, the voice call will fail.

Hand-off (transferring an End-Point's connection from a first Access Point to a second Access Point) requires the new connection between the End Point and the second Access Point to be created by the second Access Point paging the End Point. Paging may take place following the End point's disconnection from the first Access Point or alternatively the connection with the first Access Point may be maintained until a new connection with the second Access Point has been established.

The Bluetooth connection establishment procedure involves a paging device sending a sequence of ID packets, known as a 'page' addressed to a target device which must be listening for these ID packets in a state known as 'page scan'. During the handoff connection establishment the End Point is a state of continuous page scan. This may be interrupted by higher priority baseband tasks such as isochronous channel communication with either the first Access Point or some other device. The second Access Point may also have one or more higher priority isochronous channels which interrupt its paging of the End Point. In addition, the RF frequency that a device listens on whilst in the page scan state changes periodically.

Paging by the second Access Point will only be successful if the second Access Point transmits an ID packet at the RF frequency on which the End Point is page scanning while it is actually listening, i.e. not servicing some higher priority task such as an isochronous channel. While the page procedure will try all possible frequencies in the end, a method of ensuring that the page is at the correct RF frequency initially will shorten the time taken to establish a connection.

In the case where both the second Access Point and the End Point have isochronous channels to maintain, it could be that the opportunities for page and page scan do not occur simultaneously. If there is insufficient overlap of paging and page scanning such that the End Point does not receive an ID packet from the second Access Point, then no new connection will be established and the End Point's connection to the network will be lost.

30

Summary of the Invention

According to a first aspect of the present invention, a method of hand-off in a wireless communications network in which an end point connection is transferred from a first access point to a second access point, comprises the step of:

transferring timing information relating to the end point to the second access point via the first access point prior to establishing a connection between the end point and the second access point.

5 The transfer of the timing information relating to the end point allows a connection between the second access point and the end point to be established efficiently.

According to a second aspect of the present invention, a wireless network comprises a plurality of access points to which an end point can connect, wherein the access point and/or end point are adapted so that hand-off of a connection between
10 the end point and one access point to another access point is effected by the method of the first aspect.

Brief Description of the Drawings

Examples of the present invention will now be described in detail with
15 reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a network according to the present invention;

Figure 2 is a schematic diagram of the Access Server of Figure 1;

Figure 3 is a schematic diagram of the Access Point of Figure 1; and,

20 Figures 4 to 7 are examples of alternative network arrangements;

Figure 8 shows a section of a network illustrating a hand-off of a connection between two Access Points; and,

Figure 9 illustrates the sequence of communications between the devices involved in a hand-off.

25

Detailed Description

Figure 1 shows a basic network arrangement according to the present invention. As shown, the network includes an Access Server 1 which is coupled to a number of local area network Access Points 2. The Access Points 2 are designed to
30 communicate with a number of Bluetooth enabled communications devices 3,4,5,6,7,8 using Bluetooth connection.

In this scenario, the Bluetooth communication devices 3,4,5,6,7,8 can include devices such as a personal computer, laptop or the like which is fitted with a Bluetooth adapter, a specialised Bluetooth laptop, a Bluetooth enabled phone or mobile phone,
35 a WAP Internet phone, a Bluetooth enabled personal data assistant (PDA) or a

Bluetooth headset which are capable of establishing voice calls via the Bluetooth connections with the Access Points.

In fact under normal circumstances, the Access Server and Access Point can communicate with any Bluetooth enabled device. These include not only PCs, PDAs, and laptops but any of the following that have a Bluetooth port; a truck, a refrigerator, a baggage trolley, a keyboard etc, although this is not relevant for the purpose of the present invention.

The Access Server 1 is also optionally connected to a local area network having a number of end stations 11,12,13. In this example, this allows the Access Server to be integrated with currently existing local area networks within a building.

The Access Server 1 can also be connected to a remote communications network 14, which in this example is the Internet. This allows the communications devices coupled to the Access Server to communicate with remote users 15 or Access Servers of other remote sites 16.

Accordingly, the Access Points 2 allow voice calls to be made by and received by the Bluetooth communications devices 3,4,5,6,7,8 in turn allowing voice calls to be made using the LAN 10 and the Internet 14, via the Access Server 1. In this case, the Access Server operates as a call controller, as will be described in more detail below.

The Access Server is shown in more detail in Figure 2.

The Access Server may include an Internet interface 20, an Access Point interface 21, a LAN interface 22 and a PBX interface 23, all of which are interconnected via a bus 24. A microprocessor 25 and a memory 26 which are provided for processing and storing the operating software, are also coupled to the bus 24. An input/output device 27 is also provided.

The processor 25 is typically an x86 type processor operating a Linux type operating system such as Red Hat Linux. This is particularly advantageous as the Linux system is widely used as the operating system for a number of different software applications. Accordingly, the system can implement a wide variety of standard operating software for network servers and the like, as well as allowing third parties the opportunity to modify existing software and develop their own software. However, any suitable form of processing system may be used.

In addition to these features, it is also possible to include a number of Bluetooth radios 28, and a GPRS transceiver 29, both of which are coupled to the BUS 24.

A range of radios are supported, including standard and enhanced range devices.

Similarly, the Bluetooth design of the Access Server and the Access Point offers capabilities beyond the basic Bluetooth specification. These include advanced control of Bluetooth device state to improve throughput, and control of broadcast and multicast traffic streams to/from Bluetooth devices.

In this example, four different interfaces 20,21,22,23 are shown. However, it is not essential for the Access Server 1 to include all of these interfaces, depending on the particular configuration which is to be used, as will be explained in more detail below.

Thus, in order to enable Bluetooth voice calls to be made between the Bluetooth communication devices and remote third parties, all that is required is for the Access Server to include the Access Point interface 21, with appropriately connected Access Points 2, and one of the Internet interface 20, the LAN interface 22, or the PBX interface 23, coupled to an appropriate communications device. Thus, for example, the LAN interface 22 could be coupled to an Ethernet phone via the LAN 10. Further examples will be described in more detail below. Alternatively, the Access Point interface need not be used if the Bluetooth radios 28 are used instead. However, this will become clearer when various network configurations used by the Access Server are described in more detail below.

The Internet interface 20 is used primarily for providing an ISDN connection to an Internet service provider. However, the system can be reconfigured to use Ethernet, DSL or a POTS modem for Internet connectivity. Thus, this allows VoIP calls to be transferred via the Internet 14.

The Access Point interface 21 is effectively an Ethernet interface which is adapted to operate with the Access Points, as will be explained in more detail below.

The LAN interface 22 is normally configured to be an Ethernet interface. However, this can be adapted to provide token ring or other forms of communication as required. Accordingly the LAN 10 can comprise an Ethernet, Token Ring or other similar network.

In order to be able to handle different communications protocols, each of the interfaces 20,21,22 will include a processor and a memory. The processor operates software stored in the memory which is appropriate for handling the required communications protocol. Thus in the case of the LAN interface 21, the default protocol is Ethernet. However, if alternative protocols such as Token Ring or ATM are

used, then the software is adapted to translate the format of the data as it is transferred through the respective interface.

An Access Point according to the present invention is shown in Figure 3. The Access Point includes an Access Server interface 30, for connecting the Access Point to the Access Server. The Access Server interface 30 is connected via a BUS 31 to a processor 32 and a memory 33. The BUS is also coupled to a number of Bluetooth radios 34 (only one shown) providing enhanced capabilities such as improved bandwidth and call density.

The processor 32 is typically a processor system that can include one or more processors, of the same or different types within the system. For example, the processor system could include, but is not be limited to, a RISC (Reduced Instruction Set Computer) processor and a DSP (Digital Signal Processor) processor.

In use, the Access Points are usually connected to the Access Point interface 21 using a daisy chain Ethernet connection. This is particularly advantageous as it allows a large number of Access Points 2 to be connected in series via a single wire to the Access Point interface 21. In this case, power can be supplied to the Access Points 2 either via the connection from the Access Server 1, or via separate power supplies (not shown) connected to each of the Access Points 2 as required.

As an alternative however, the Access Points 2 can be connected to the Access Server 1 via an Ethernet hub. This would allow a larger number of Access Points 2 to be connected to each Access Server 1.

In use, each Access Point 2 is able to communicate with a number of communications devices 3,4,5,6,7,8 which are in range of the respective radio 34. Any data received at the radio is transferred to the memory 33 for temporary storage. The processor 32 will determine from the data the intended destination. If this is another Bluetooth device within range of the Access Point, the data will be transferred via the radio 34 to the appropriate communications device 3,4,5,6,7,8. Otherwise the data will be transferred via the BUS 31 to the Access Server interface 30 and on to the Access Server 1.

Upon receipt of the data by the Access Server 1, the Access Point interface 21 will temporarily store the data in the memory whilst the processor determines the intended destination of the data. The processor may also operate to translate the format of the data, if this is necessary. The data is then routed by the Access Server to the intended destination on either the LAN 2, the Internet 14 or alternatively, to a PBX network, as will be described in more detail below.

The traffic from Bluetooth devices (arriving through an Access Point or the Access Server) can be sent to the LAN through a number of different mechanisms; one is routing, another uses a technique called Proxy ARP to reduce the configuration needed. These mechanisms are bi-directional and also connect traffic from the LAN to Bluetooth devices.

Similarly, data can be transferred from the Access Server, via the Access Point interface 21 to an Access Point 2. In this case, the Access Point 2 receives the data and transfers it into the memory 33. The processor 32 then uses the data to determine the intended destination communication device before routing the data appropriately.

A number of different network configurations for transferring voice type calls via the Access Server are shown in Figures 4 to 7.

Figure 4 shows an example in which a connection to a PBX 40 is implemented, the Access Server 1 will have the ability to associate communications devices 3,4,5,6,7,8 such as Bluetooth phones and handsets as extensions of the PBX. This allows Bluetooth enabled phones to call phones 41,42 on the PBX 40, as well as making calls to public telephone networks 43, such as the PSTN (Public Switched Telephone Network) or POTS (Plain Old Telephone System).

For example, this enables the Bluetooth phone or headset to ring at the same time, or instead of a users desk phone 41,42. Indeed, the invention enables the Bluetooth phone to have all the features offered by the PBX as a minimum functionality; on top of this, some new features can be added.

The use of Bluetooth 3-in-1 phones which are capable of both Bluetooth and cellular communications allows users to use their cellular phone as their desk phone when in the office.

Where the PBX has no appropriate support for ISDN, the Access Server PBX interface 23 can be connected directly to the public network 43 as shown by the dotted line, to provide direct dial-in and dial out to Bluetooth phones and headsets.

The Access Points 2 can also provide VoIP (Voice Over IP) connectivity to the Access Server, as shown in Figure 5. In this example, the Access Server 1 is connected to the PBX 40 through a VoIP gateway 45 connected to the LAN. The Access Points implement voice compression algorithms hence providing a scalable VoIP solution (i.e. compression ability is increased with each Access Point).

In the example of Figure 6, VoIP replaces the PBX 40 to allow connection to the telephone network 43. This is achieved by using a VoIP gateway 45 positioned

between the Internet 14 and the phone network 43, to allow all phone calls to be transferred via the Internet 14 and the Access Server 1. In this example Ethernet phones 46,47 can connect directly to the LAN 10, whilst the Access Server 1 provides a gateway from Bluetooth phones and headsets to the Internet and hence on to the
5 phone network 43.

In the example of Figure 7, the GPRS system is used to provide constant on-line connection to the Internet. This is achieved using the GPRS transceiver 29 to provide the GPRS connection to the Internet 14, and the phone network 43, and using the Bluetooth radios 28 to provide the connection from the Access Server 1 to the
10 communications devices 3,4,5,6,7,8. In circumstances where GPRS services do not provide sufficient bandwidth for all applications, the system may use dial-up ISDN to increase bandwidth. The always on full time connection to the Internet 14 provided by GPRS enables features such as VPN and public Web serving to be used, especially where additional bandwidth can be dialled up on demand.

15 In a mobile environment, it will be normal to use GSM phones for voice support. There may be added value in providing mobile voice connectivity via the Access Server.

Thus, the Access Server 1 provides wireless Internet and LAN access to a variety of Bluetooth enabled communications devices including PCs, printers, PDAs and WAP phones. It will also provide services specially tailored for PDAs through the
20 use of OBEX (Object Exchange protocol) and WAP technology in the Access Server 1.

It will be appreciated from this that many users may be connected to the Access Server via the Access Points at any one time. Accordingly, it is necessary for
25 the entire network system to operate a registration procedure to ensure that only authorised users of the system can have access.

Accordingly, the Access Server 1 stores a list of authorised users in the memory 26. In each case, a user name and password is provided for the user so that when they first access the system, the user name and password must be entered.

30 The Access Server and Access Point can implement a number of different security solutions. These range from low level authentication procedures inherent in Bluetooth devices, to high level security features which allow simple, easy to use and deploy services which operate in conjunction with or instead of Bluetooth specific security features. This allows a deployment of the Access Server & Access Point in
35 a range of sites and applications.

Once this has been completed, the Access Server will associate a device indication with the associated user name and password. This ensures that a record is maintained of which device is being used by the user. Accordingly, any subsequent data addressed to the user can be sent directly to the device.

5 Thus, if the user is using a wireless communications device 3,4,5,6,7,8, the Access Server will store an indication of the device, either as a particular address, device identifier, or the like together with the user name and password. If any E-mail or the like is then received for that particular user, this can be directed to the device automatically.

10 The Access Server can store data concerning which radio 34,28 the user's communication device 3,4,5,6,7,8 is attached to. Every time a user's communication device 3,4,5,6,7,8 moves from one radio 28,34 to another there is a disconnection and reconnection process. To make this as seamless as possible a "roaming" capability is operated by the processor to allow the controlled hand-off from one radio to
15 another.

Figure 8 shows a Bluetooth network including a mobile end point device 50 which initially has established a connection with a first Access Point 51. The end point 50 is shown as a Bluetooth mobile telephone but may equally be a Bluetooth PDA, a Bluetooth headset or the like. The first Access Point 51 is connected to an Access
20 server 53 over an ethernet connection via a second Access Point 52 in a daisy chain configuration. There are a number of reasons that it may be desirable to hand the connection of the mobile telephone to the network from the first Access Point to the second Access Point. For example, the mobile telephone may move away from the first Access Point towards the second Access Point causing the link with the first
25 Access Point to become degraded and the quality of the connection available from the Second Access Point to become better than that from the first Access Point. Another reason is load balancing. The first Access Point might be handling more connections than the second Access Point and hence using more bandwidth. It may then be desirable to move the connection of the mobile telephone to the second Access point
30 to provide a better quality of service.

Figure 9 illustrates a hand-off mechanism in the network of Figure 8 in accordance with the present invention. A mobile end point device, a first network Access Point (NAP1) and a second network Access Point (NAP2) are shown schematically. NAP1 and NAP2 are connected over a wired backbone network, such

as an ethernet. An optional central hand-off controller is shown which is part of the wired backbone network.

At step 100 the devices are initialised. Step 101 is the calculation and maintenance of clock offsets between the two Access Points. Bluetooth connections are based on a Fast Frequency Hopping Spread Spectrum (FFHSS) system in which packets are transmitted in regular time slots on frequencies defined by a pseudo random sequence. The time slots are numbered according to the Bluetooth clock of the master of a particular connection. All Bluetooth devices connected to the master are time and hop synchronized. NAP1 and NAP2 maintain a record of their clock offsets. This can be done using a time synchronization protocol, such as Network Time Protocol over the backbone network, or, as they are spatially fixed relative to each other and so always within range, by periodically establishing a Bluetooth connection between NAP1 and NAP2. A knowledge of the clock offset allows subsequent connections to be established more quickly. Following an initial Bluetooth connection between NAP1 and NAP2, subsequent connections can be established quickly from an estimate of the rate of drift between Bluetooth baseband clocks. Once connected again the clock offset can be calculated more accurately. Subsequent connections can then be made in a similar fashion.

Step 102 shows that each of the devices in the network may establish connections with other network devices. As will be described, these connections may be high priority connections which interfere with the establishing of new connections.

Step 103 shows a connection between the end point and NAP1 is established, using an Asynchronous Connectionless Link (ACL), Bluetooth network Encapsulation Protocol (BNEP) and network layer protocols.

At step 104 a hand-off is triggered. A hand-off can be triggered by a number of events. A request for hand-off using a hand-off protocol conveys the occurrence of a hand-off trigger. The hand-off is requested by a BNEP message or by using a protocol over the backbone network.

At step 105, NAP1 uses the Link manager Protocol (LMP) to read the offset of the end point's Bluetooth clock relative to NAP1's Bluetooth clock.

Step 106 is the optional, additional step of using a BNEP control message to send a mask of those slots available on the end point's clock for page scanning, between those slots reserved for higher priority tasks such as isochronous channels associated with other connections.

At step 107 the hand-off is requested to NAP2. At this point the clock data read at steps 105 and 106 is transferred to NAP2, either via the backbone network (optionally via an intermediate controller), or via a Bluetooth connection.

At step 108, if required, the time slots used by NAP2 for asynchronous connections may be rescheduled to facilitate a connection to the end point.

At step 109 NAP2 acknowledges the hand-off request

At step 110 the connection between the end point and NAP1 is placed in sniff, hold or park mode, or is disconnected, in preparation for a new connection between the end point and NAP2.

At step 111 the end point enters a page scan mode. In order to establish a new connection with the network Access Point the end point enters a page scan mode in which it listens for "pages". A device which is paging sends a sequence of ID packets, known as a page, to a target device which must be listening for the ID packets.

The end point is in a page scan state at step 111 but this state may be interrupted by higher priority tasks and the maintenance of other connections set up at step 102. For example, synchronous connections, such as SCO links for voice, will interrupt page scanning.

Furthermore, the RF channel on which a device in a page scan state listens changes periodically. The Rf channel frequency pattern can, however, be calculated using the device's address and information about its Bluetooth clock. It is this information, together with scheduling information that has been sent to NAP2 at step 107.

At step 112 NAP2 pages the end point. The page is performed based on a knowledge of the clock offset between NAP2 and the end point, and a knowledge of the scheduled commitments of the end point. Thus the page can be performed in a slot in which the end point is in a page scan mode and at the RF frequency channel which the end point is listening for at that time.

At step 113 the connection between NAP1 and the end point is disconnected, if it has not already been disconnected at step 110.

At step 114 the BNEP layer is established between the end point and NAP2.

Thus the invention allows the hand-off of a connection between two Access Points to be effected in a short time and reduces the likelihood of a loss of connectivity for the end point device.

CLAIMS:

1. A method of hand-off in a wireless communications network in which an end point connection is transferred from a first access point to a second access point,
5 comprising the step of:
transferring timing information relating to the end point to the second access point via the first access point prior to establishing a connection between the end point and the second access point.
- 10 2. A method according to claim 1, in which the end point and the access points each operate one or more radio transceivers.
3. A method according to claim 1 or 2, in which the end point and the access points each operate one or more Bluetooth enabled radio transceivers.
- 15 4. A method according to claim 3, wherein the timing information includes information about the end point's Bluetooth clock.
5. A method according to any preceding claim , wherein the timing information
20 includes scheduling information.
6. A method according to any preceding claim, wherein the first access point and the second access point are connected via a wired connection, and the timing information is transferred to the second access point over the wired connection.
- 25 7. A method according to any preceding claim, wherein the timing information is transferred from the first access point to the second access point via a wireless connection.
- 30 8. A method according to any preceding claim, in which the access points are connected to a common access server to form a wireless network.
9. A method according to any preceding claim, in which the end point is a mobile device.

10. A method according to any preceding claim, in which the relative position of the access points is fixed.

5 11. A wireless network comprising a plurality of access points to which an end point can connect, wherein the access point and/or end point are adapted so that hand-off of a connection between the end point and one access point to another access point is effected by the method of any preceding claim.

Fig.1.

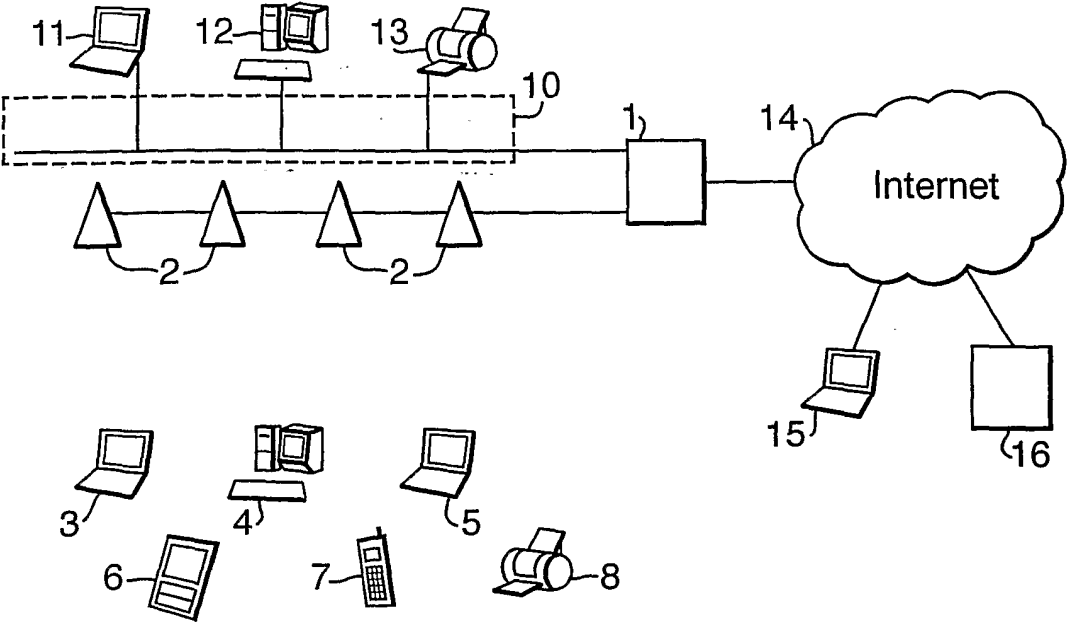


Fig.2.

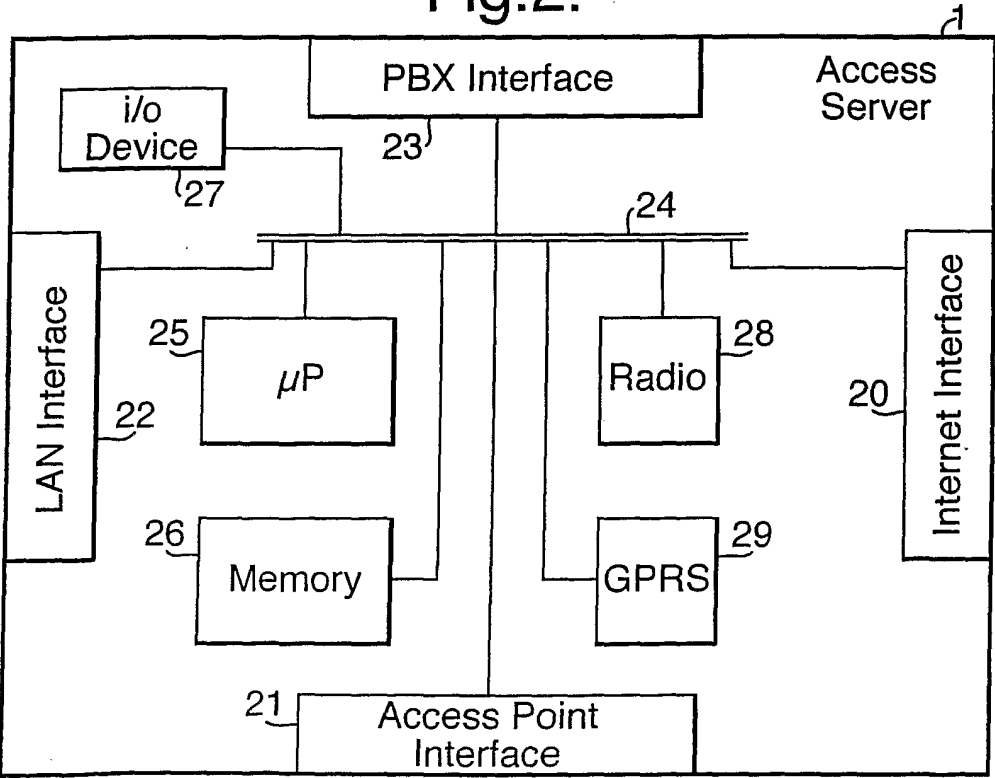


Fig.3.

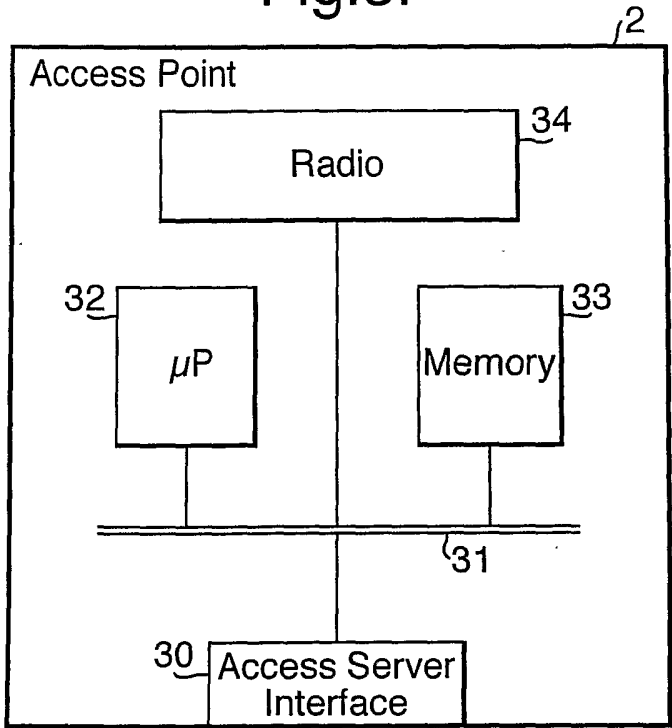
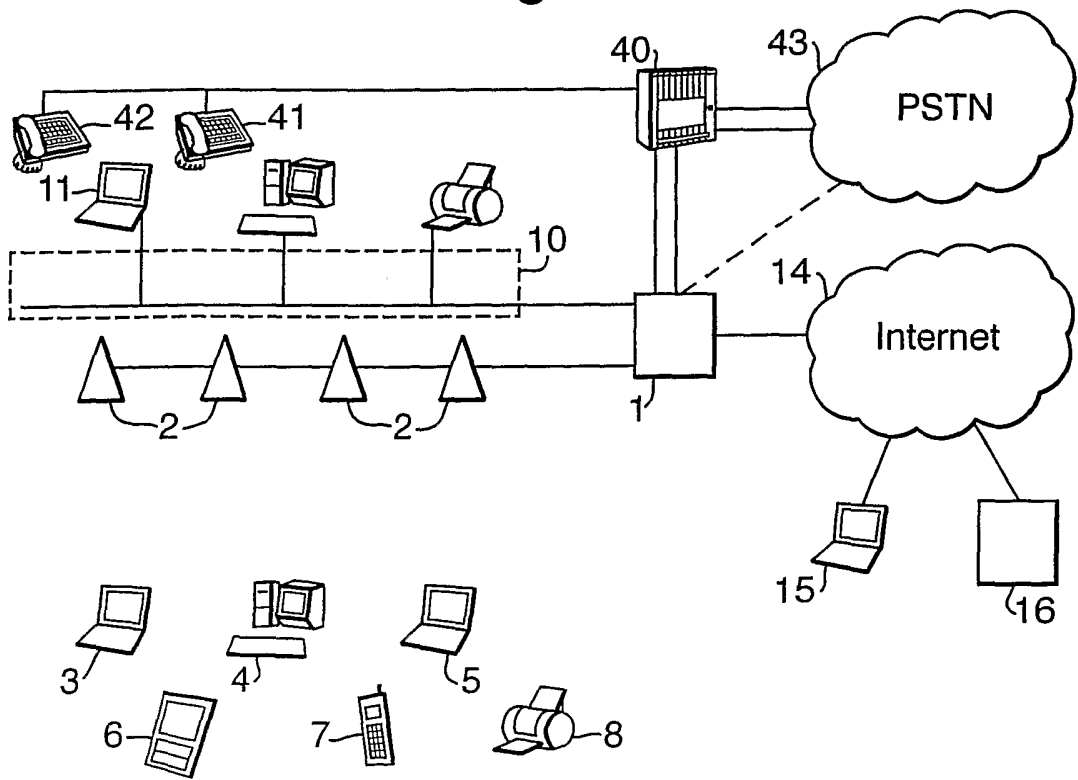


Fig.4.



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Fig.5.

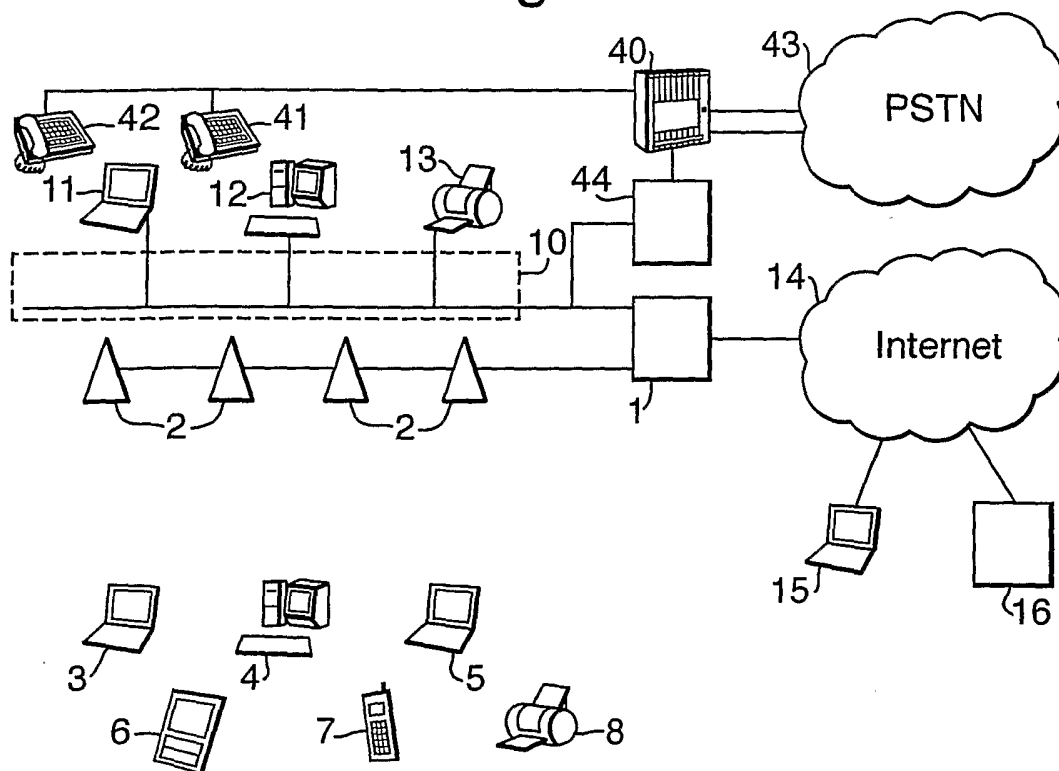
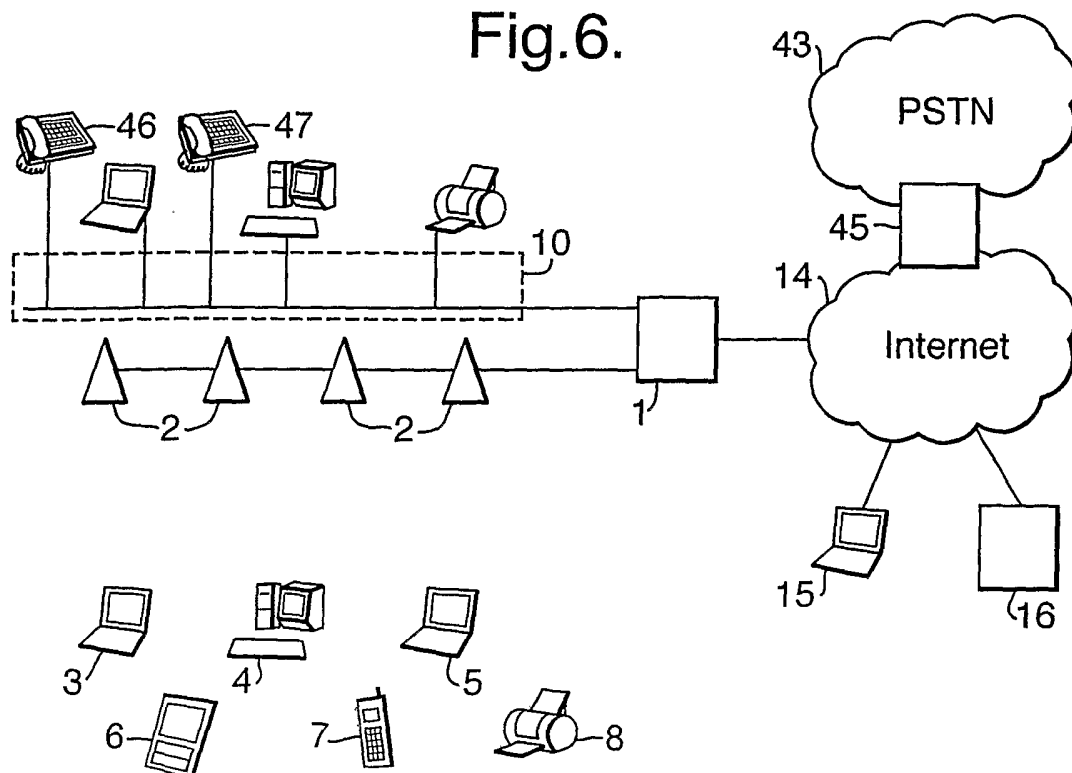
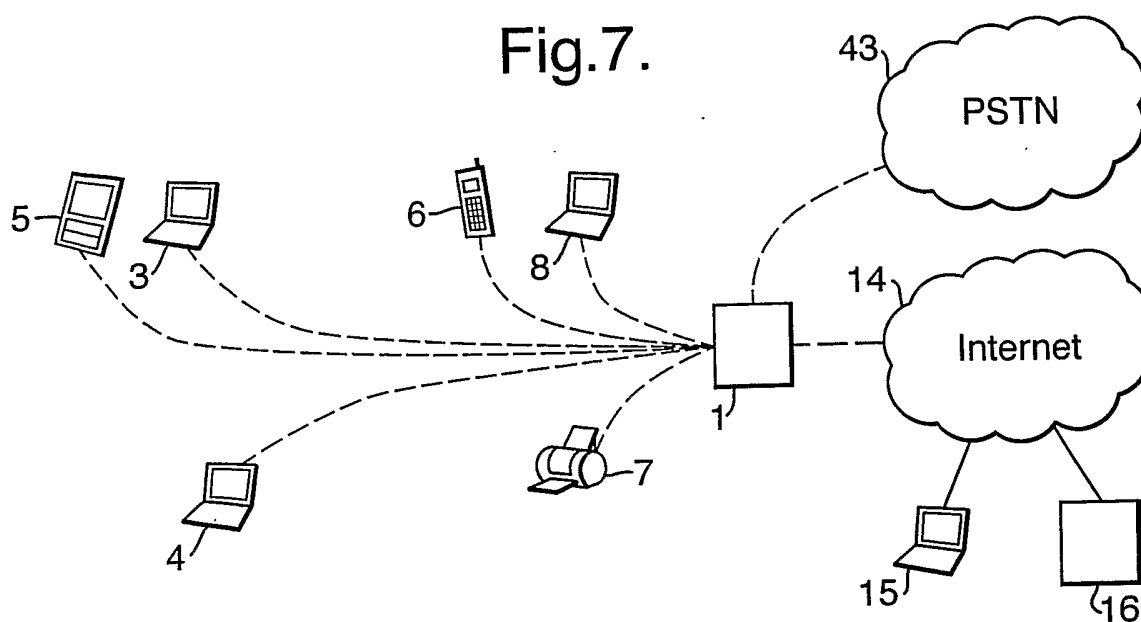


Fig.6.



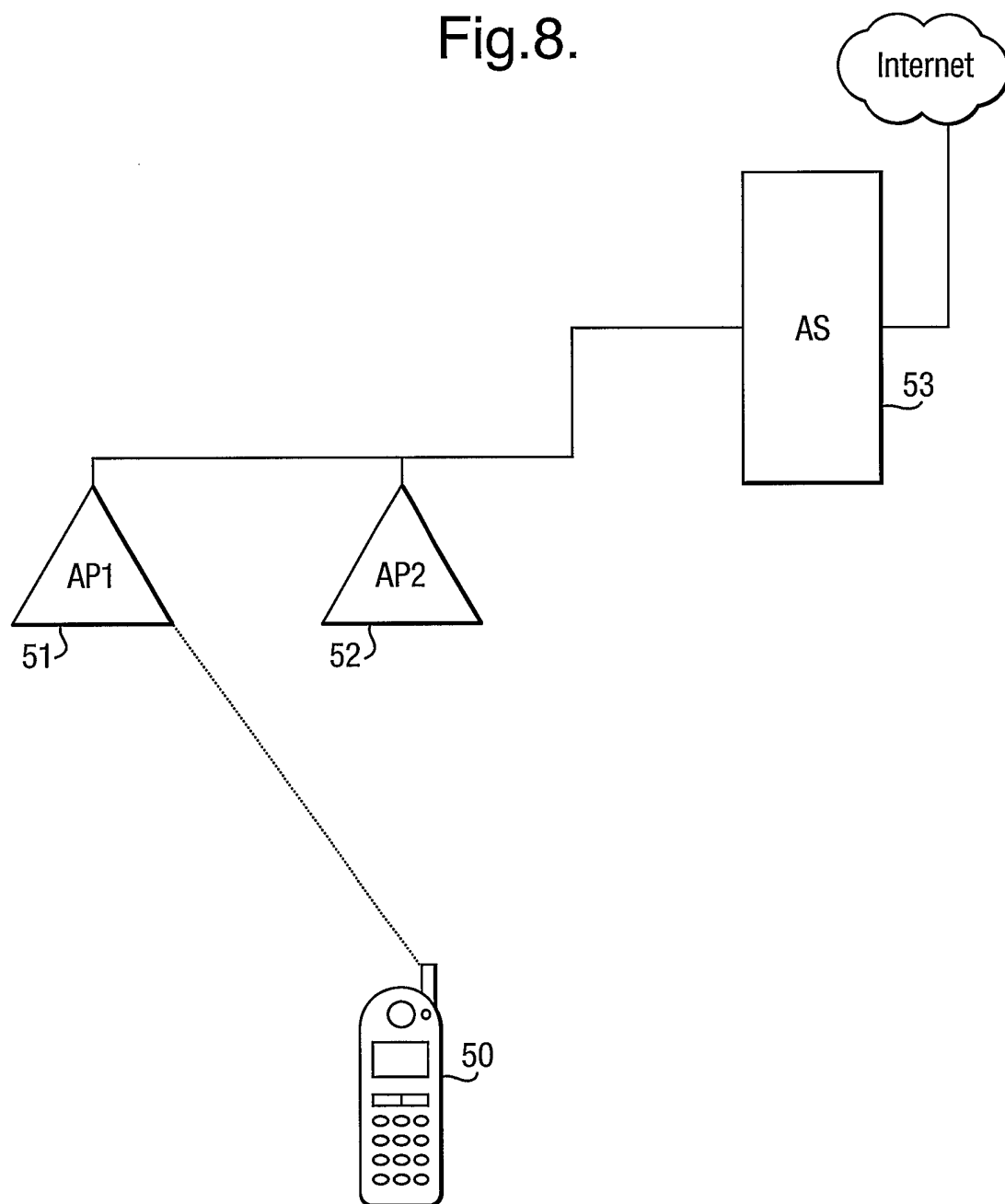
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Fig.7.



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Fig.8.



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Fig.9.

