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Wireless Communication

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Abstract - Wireless communication is the transfer of information over a distance without the use of electrical conductors or "wires". Applications of wireless communication are mobile, Bluetooth, Wi-Fi, GPS, etc. 4G is being developed to accommodate the quality of service (QoS) and rate requirements set by forthcoming applications MMS, video chat, mobile TV, HDTV content, Digital Video Broadcast minimal service like voice and data, and other streaming services for "anytime-anywhere". Bluetooth is a wireless protocol utilizing short-range communications technology facilitating data transmission over short distances (10cm, 10m and 100m) from fixed and/or mobile devices, creating wireless personal area networks (PANs). Wi-Fi is a wireless LAN technology that enables laptop PCs, PDAs, and other devices to connect easily to the internet. In this paper mainly 4G mobile, Bluetooth, Wi-Fi are covered.

Keywords **– Wireless Communication, 4G, Bluetooth, WI-FI, WLAN.**

1. Introduction

A wireless network uses radio signals or microwaves to broadcast data and information. Rather than being transmitted through traditional coaxial, CAT5 Ethernet or other standard wired methods, the data is beamed out over the airwaves. Most wireless network equipment available today is compatible with both 802.11b and the faster 802.11g which operates at speeds up to 54mbps. There is also a new, emerging wireless network standard, 802.11n, which theoretically increases both the speed and the range of the wireless network. Wireless network speeds are affected by obstructions such as walls and floors. Most wireless network equipment, for consumers in particular, also operates in the 2.4Ghz frequency range. This is the same range as other household devices such as cordless phones, baby monitors, etc. The interference from these devices, as well as microwave ovens and other electrical interference can greatly impact the range, speed and quality of your wireless network.

Wireless networks serve as the transport mechanism between devices and among devices and the traditional wired networks (enterprise networks and the Internet). Wireless networks are many and diverse but are frequently categorized into four groups based on their coverage range: Wireless Wide Area Networks (WWAN); Wireless Metropolitan Area Network (WMAN); Wireless Local Area Networks (WLANs), and Wireless Personal Area Networks (WPAN). WWAN includes wide coverage area technologies such as 2G cellular, Cellular Digital Packet Data (CDPD), Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS) and WMAN represents wireless internet connection at broadband speeds within city or suburbs, it includes 802.16. WLAN, representing wireless local area networks, includes 802.11, HiperLAN, and several others. WPAN represents wireless personal area network technologies such as Bluetooth and IR.

2. 4G Mobile

One may wonder why 4G is needed when 3G has not yet been fully implemented. Unfortunately, 3G has failed to live up to its promise. Firstly, 3G's maximum data transfer rate of 384Kbps is much lower than the expected 2Mbps. In addition, there are presently several hybrid versions of 3G that are implemented because companies were unable to agree on a set technology standard for 3G. Perhaps the most influential reason for the fall of 3G and rise of 4G is the cost related to the creation of 3G networks. In Europe and Asia, several companies have invested upwards of a billion Canadian dollars on licensing and implementation of 3G networks. It is expected that these companies will not show a profit until about 2011 because of the lack of support for 3G. 4G is based entirely on packet switched networks. In addition, all 4G networks will be digital and will provide higher bandwidths of up to 100Mbps. 4G is actually a collection of previous standards as opposed to an entirely new standard.

Standards such as 3G, and Bluetooth will be incorporated into the 4G standard along with what can be thought of as "glue" which will connect all of these elements

together. This use of previous technologies is what makes 4G so attractive in comparison to other technology standards.

Fourth-generation (4G) mobile systems dictate entirely new approaches and novel infrastructure solutions to seamlessly integrate the existing wireless technologies including wireless broadband (WiBro), 802.16e, CDMA, wireless LAN, Bluetooth, and etc.

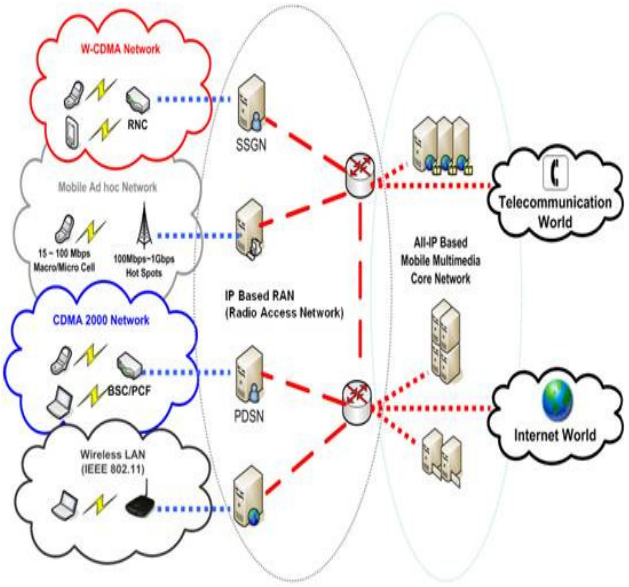

Fig 1. Mobile Network

The key features of 4G mobile systems can be summarized as follows. First, 4G mobile systems are all-IP based heterogeneous networks that allow users to use any system at any time and anywhere. Second, 4G mobile systems provide end-users with high-speed, large volume, good quality, global coverage, and flexibility to roam between different types of technologies. Finally, 4G mobile systems provide high-data-rate services to accommodate numerous multimedia applications such as video conferencing, on-line gaming, etc. Owing to such characteristics, we have to face a number of challenges to migrate current systems to 4G.
4G is the Fourth Generation Wireless Network Communications Technology standard. When implemented, users of 4G devices will have the ability to access applications ranging from basic voice communications to seamless real-time streaming video. Although it is in the research and development stage, 4G is expected to be globally available to the public between 2006 and 2010. At present the download speed for imode data is limited to 9.6 kbit/sec which is about 6 times slower than an ISDN (Integrated services digital network) fixed line connection. Recently, with 504i handsets the download data rate was increased 3-fold to 28.8kbps. However, in actual use the data rates are usually slower, especially in crowded areas, or when the network is "congested". For third generation mobile (3G, FOMA) data rates are 384 kbps (download) maximum, typically around 200kbps, and 64kbps upload since spring 2001. Fourth generation (4G) mobile communications will have higher data transmission rates than 3G. 4G mobile data transmission rates are planned to be up to 20 megabits per second. According to the 4G working groups, the infrastructure and the terminals of 4G will have almost all the standards from 2G to 4G implemented. Even though the legacy systems are in place to be adopted in 4G for the existing legacy users, going forward the infrastructure will however only be packet based, all-IP. Also, some proposals suggest having an open platform where the new innovations and evolutions can fit.

The technologies which are being considered as pre-4G are used in the following standard version: WiMax, WiBro, 3GPP Long Term Evolution and 3GPP2 Ultra Mobile Broadband.
4G is being developed to accommodate the quality of service (QoS) and rate requirements set by forthcoming applications like wireless broadband access, Multimedia Messaging Service, video chat, mobile TV, High definition TV content, Digital video broadcast, minimal service like voice and data, and other streaming services for "anytime-anywhere".

The 4G working group has defined the following as objectives of the 4G wireless communication standard:

- A spectrally efficient system (in bits/s/Hz and bits/s/Hz/site)
- High network capacity: more simultaneous users per cell
- A nominal data rate of 100 Mbit/s while the client physically moves at high speeds relative to the station, and 1 Gbit/s while client and station are in relatively fixed positions
- A data rate of at least 100 Mbit/s between any two points in the world
- Smooth handoff across heterogeneous networks
- Seamless connectivity and global roaming across multiple networks

- High quality of service for next generation multimedia support (real time audio, high speed data, HDTV video content, mobile TV, etc)
- Interoperability with existing wireless standards and
- An all IP, packet switched network

In summary, the 4G system should dynamically share and utilise network resources to meet the minimal requirements of all the 4G enabled users.

2.1 Features of 4G

The provision of megabits/second data rates to thousands of radio and mobile terminals per square Kilometers presents several challenges. The features of key technology i.e. 4G technology, permit the progressive introduction of such a networks without disturbing existing investment to achieve high capacity at low cost. These features are as follows.

- Entirely packet-switched networks.
- All network elements are digital.
- Higher bandwidths to provide multimedia services at lower cost (up to 100Mbps).
- Tight network security.
- Adaptive array technology
- Ultra wide band technology
- Simulation and analysis of advanced adaptive modulations/coding Schemes.
- Reconfigurable radio systems.
- Self- organizing networks end-to-end mobile IP and adaptive QOS (Quality of Service)
- Simulation and analysis of MIMO techniques with multi-element array antennas at both ends of the link.

2.2 Applications of 4G

The killer application of 4G is not clear, though the improved bandwidths and data throughput offered by 4G networks should provide opportunities for previously impossible products and services to be released. Perhaps the "killer application" is simply to have mobile always on Internet, no walled garden and reasonable flat rate per month charge. Existing 2.5G/3G/3.5G phone operator based services are often expensive, and limited in application.

Already at rates of 15-30 Mbit/s, 4G should be able to provide users with streaming high-definition television. At rates of 100 Mbit/s, the content of a DVD, for example a movie, can be downloaded within about 5 minutes for offline access. Fixed WiMax and Mobile WiMax are different systems, as of July 2007, all the deployed WiMax is "Fixed Wireless" and is thus not 4G. Mobile WiMAX and IEEE 802.20 must meet all the requirements for mobile Internet access. It supports multiple handoff, power-saving mechanisms for mobile devices, advanced QoS and low latency for improved support of real-time application WIMAX (Worldwide Interoperability for Microwave Access and Wireless Broadband) and WIBRO (Wireless Broadband) . WiBro is the service name for Mobile WiMAX in Korea.

3. Wi-Fi

Wi-Fi uses both single-carrier direct-sequence spread spectrum radio technology (part of the larger family of spread spectrum systems) and multi-carrier orthogonal frequency-division multiplexing (OFDM) radio technology.

Wi-Fi or short for "wireless fidelity" is the term for a high-frequency wireless local area network (WLAN). Wi-Fi technology is gaining acceptance as an alternative to a wired LAN. The 802.11b Wi-Fi technology operates in the 2.4 GHz range offering data speeds up to 11 megabits per second. Modulation used in 802.11 has historically been phase-shift keying (PSK). The modulation method selected for 802.11b is known as complementary code keying or CCK, which makes possible high data speed and is less susceptible to multipath-propagation interference. A Wi-Fi enabled device such as a personal computer, video game console, mobile phone, MP3 player or personal digital assistant can connect to the Internet when within range of a wireless network connected to the Internet. The coverage of one or more interconnected access points — called a hotspot — can comprise an area as small as a few rooms or as large as many square miles covered by a group of access points with overlapping coverage.

Table 1 - Wi-Fi Standards

Standard	speed	frequency band	
802.11	2 Mbps	2.4 GHz	(1997)
802.11a	54 Mbps	5 GHz	(1999)
802.11b	11 Mbps	2.4 GHz	
802.11g	54 Mbps	2.4 GHz	

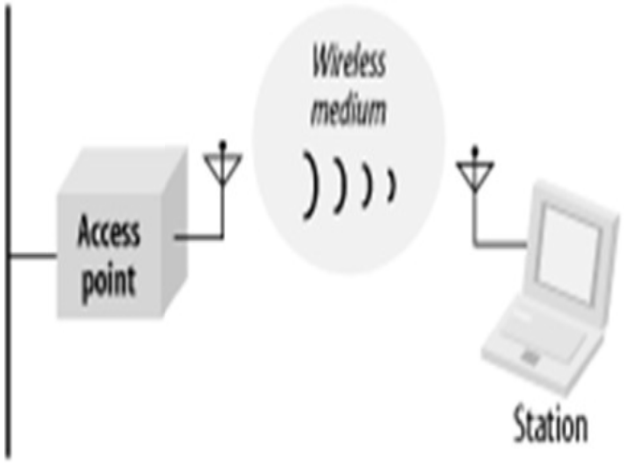

Fig 2- WLAN Architecture

3.1. Ad-Hoc Mode

Peer to peer setup where clients can connect to each other directly. Generally not used for business networks.

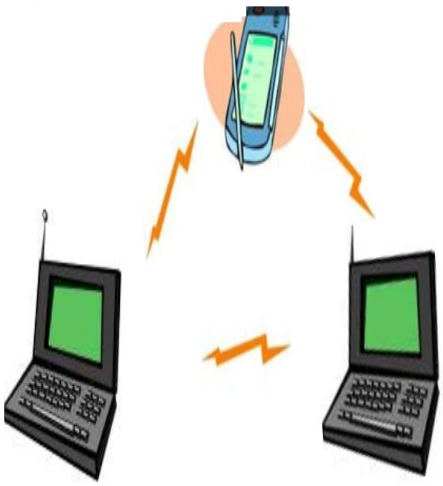

Fig 3- Ad-Hoc Structure

Mobile stations communicate to each other directly. It's set up for special purpose and for short period of time.

3.2. Infrastructure Mode

There is an access point (AP) which becomes the hub of "Star Topology".

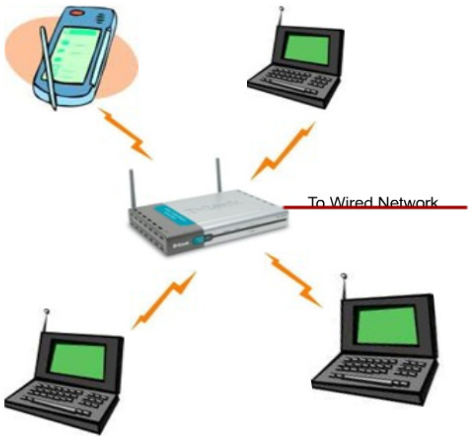

Fig 3- Star technology

system to a non-IEEE 802.11 network. The integration function is specific to the distribution system used and therefore is not specified by 802.11,except in terms of services it must offer Any communication has to go through AP. If a mobile station(MS),like computer, a PDA, or a phone, wants to communicate with another MS, it needs to send information to AP first, then AP sends it to destination MS. Multiple APs can be connected together and handle a large number of clients. It is used by majority WLANs in homes and businesses.

3.3. Wi-Fi network Services

3.3.1. Distribution and Integration

This service is used by mobile stations in infrastructure network every time they send data. Once a frame has been accepted by an access point, it uses the distribution service to deliver the frame to its destination. Any communication that uses an access point travels through the distribution service, including communications between two mobile stations associated with the same access points.

Integration is service provided by the distribution system; it allows the connection of distribution.

3.3.2. Re-association and Disassociation

When a mobile station moves between basic service areas within a single extended service area, it must evaluate signal strength and perhaps switch the access point with which it is associated. Re-associations are initiated by mobile stations when signal conditions indicate that a different association would be beneficial; they are never initiated by access point. After the re-

association is complete, the distribution system updates its location records to reflect the reachability of mobile station through a different access point. To terminate an existing association, stations may use the disassociation service. When stations invoke the disassociation service, any mobility data stored in the distribution system is removed. Once disassociation is complete, it is as if the station is no longer attached to the network. It is a polite task to do during station shut down process. The MAC is however designed to accommodate stations that leave the network without formally disassociating.

3.3.3. Authentication/Deauthentication

Physical security is a major component of a wired LAN security solution. Wired network's equipment can be locked inside offices. Wireless networks can't offer the same level of physical security, however, and therefore must depend on additional authentication routines to ensure that users accessing the networks are authorized to do so. Authentication is a necessary prerequisite to association because only authenticated users are authorized to use the network.

Deauthentication terminates an authenticated relationship. Because authentication is needed before network use is authorized, a side effect of this is termination of any current association.

4. Bluetooth

Bluetooth is a wireless protocol utilizing short-range communications technology facilitating data transmission over short distances from fixed and/or mobile devices, creating wireless personal area networks (PANs). The intent behind the development of Bluetooth was the creation of a single digital wireless protocol, capable of connecting multiple devices and overcoming problems arising from synchronization of these devices. Bluetooth uses a radio technology called frequency hopping spread spectrum. It chops up the data being sent and transmits chunks of it on up to 75 different frequencies. In its basic mode, the modulation is Gaussian frequency shift keying (GFSK). It can achieve a gross data rate of 1 Mb/s. Bluetooth uses radio technology called FHSS and it performs 1,600 hops per second and uses 79 hop carriers equally spaced with 1Mhz in the 2.4 GHz ISM(industrial,scientific and medical) band. The Bluetooth specifications are developed and licensed by the Bluetooth Special Interest Group (SIG). The Bluetooth SIG consists of companies in the areas of telecommunication, computing, networking, and consumer electronics.Bluetooth technology was intended to hasten the convergence of voice and data to handheld devices.

4.1. Types of Bluetooth

4.1.1 Bluetooth1.0 and 1.0B

Versions 1.0 and 1.0B had many problems, and manufacturers had difficulty making their products interoperable. Versions 1.0 and 1.0B also included mandatory Bluetooth hardware device address (BD_ADDR) transmission in the Connecting process (rendering anonymity impossible at the protocol level), which was a major setback for certain services planned for use in Bluetooth environments.

4.1.2 Bluetooth 1.1

- Ratified as IEEE Standard 802.15.1-2002.
- Many errors found in the 1.0B specifications were fixed.
- Added support for non-encrypted channels.
- Received Signal Strength Indicator

4.1.3 Bluetooth 1.2

This version is backward-compatible with 1.1 and the major enhancements include the following:

- Faster Connection and Discovery
- Adaptive frequency-hopping spread spectrum (AFH), which improves resistance to radio frequency interference by avoiding the use of crowded frequencies in the hopping sequence.
- Higher transmission speeds in practice, up to 721 kbit/s, than in 1.1.
- Extended Synchronous Connections (eSCO), which improve voice quality of audio links by allowing retransmissions of corrupted packets, and may optionally increase audio latency to provide better support for concurrent data transfer.
- Host Controller Interface (HCI) support for three-wire
- Ratified as IEEE Standard 802.15.1-2005.

4.1.4 Bluetooth 2.0

This version of the Bluetooth specification was released on November 10, 2004. It is backward-compatible with the previous version 1.1. The main difference is the introduction of an Enhanced Data Rate (EDR) for faster data transfer. The nominal rate of EDR is about 3 megabits per second, although the practical data transfer rate is 2.1 megabits per second The additional throughput is obtained by using a different radio technology for

transmission of the data. Standard, or Basic Rate, transmission uses Gaussian Frequency Shift Keying (GFSK) modulation of the radio signal; EDR uses a combination of GFSK and Phase Shift Keying (PSK) modulation.

According to the 2.0 specification, EDR provides the following benefits:

- Three times faster transmission speed — up to 10 times (2.1 Mbit/s) in some cases.
- Reduced complexity of multiple simultaneous connections due to additional bandwidth.
- Lower power consumption through a reduced duty cycle.

The Bluetooth Special Interest Group (SIG) published the specification as "Bluetooth 2.0 + EDR" which implies that EDR is an optional feature. Aside from EDR, there are other minor improvements to the 2.0 specification, and products may claim compliance to "Bluetooth 2.0" without supporting the higher data rate. At least one commercial device, the pocket PC phone, states "Bluetooth 2.0 without EDR" on its data sheet.

4.1.5. Bluetooth 2.1

Bluetooth Core Specification Version 2.1 is fully backward-compatible with 1.1, and was adopted by the Bluetooth SIG on July 26, 2007. This specification includes the following features:

- Extended inquiry response: provides more information during the inquiry procedure to allow better filtering of devices before connection. This information includes the name of the device, a list of services the device supports, plus other information like the time of day and pairing information.
- Sniff subrating: reduces the power consumption when devices are in the sniff low-power mode, especially on links with asymmetric data flows. Human interface devices (HID) are expected to benefit the most, with mouse and keyboard devices increasing their battery life by a factor of 3 to 10. It lets devices decide how long they will wait before sending keepalive messages to one another. Previous Bluetooth implementations featured keep alive message frequencies of up to several times per second. In contrast, the 2.1 specification allows pairs of devices to negotiate this value between them to as infrequently as once ev*ery 5 or 10 seconds*.
- Encryption Pause Resume: enables an encryption key to be refreshed, enabling much stronger encryption for connections that stay up for longer than 23.3 hours (one Bluetooth day).
- Secure Simple Pairing: radically improves the pairing experience for Bluetooth devices, while increasing the use and strength of security. It is expected that this feature will significantly increase the use of Bluetooth.

4.2. Bluetooth High Speed

On March 28, 2006, the Bluetooth Special Interest Group announced its selection of the WiMedia Alliance Multi-Band Orthogonal Frequency Division Multiplexing (MB-OFDM) version of UWB for integration with current Bluetooth wireless technology.

UWB integration will create a version of Bluetooth wireless technology with a high-speed/high-data-rate option. This new version of Bluetooth technology will meet the high-speed demands of synchronizing and transferring large amounts of data, as well as enabling high-quality video and audio applications for portable devices, multi-media projectors and television sets, and wireless VOIP.

At the same time, Bluetooth technology will continue catering to the needs of very low power applications such as mouse, keyboards, and mono headsets, enabling devices to select the most appropriate physical radio for the application requirements, thereby offering the best of both worlds.

Bluetooth SIG is also developing a method of radio substitution to use an alternate MAC/PHY (such as IEEE 802.11) for application requiring more speed. It will allow Bluetooth protocols, profiles, security and pairing to be used in consumer devices on top of the already present 802.11 radio, when necessary.

4.1.6. Bluetooth 3.0

The next version of Bluetooth after v2.1, code-named Seattle (the version number of which is TBD) has many of the same features, but is most notable for plans to adopt ultra-wideband (UWB) radio technology. This will allow Bluetooth use over UWB radio, enabling very fast data transfers of up to 480 Mbit/s, while building on the very low-power idle modes of Bluetooth.

4.3. Advantages

Bluetooth was designed to allow low bandwidth wireless connections to become easy to use so even those who are new to wireless can use them. Version 1.1 of Bluetooth

describes a low power, short range wireless networking technology that uses radio waves to send data at rates up to 720 kilobits a second .the specification for Bluetooth supplies for different classes of radio that allow transmission ranges of up to 100 meters by boosting the radio power. The technology of Bluetooth isn't limited to line of sight transmission since it uses directional waves that are capable of transmitting through many obstructions. Bluetooth is an industry standard communication of wireless, meaning that it enables the connection of other devices as well, such as cell phones, computers, digital cameras, & other types of electronic devices.

The specification of Bluetooth defines a radio system and a "stack" of protocol layers and profiles. The highest layer is the application layer, while the lowest layer is the radio. The wireless technology of Bluetooth is positioned to revolutionize the personal connectivity market by providing freedom from inconvenient fixed type lines. The specification for Bluetooth eliminates the need for cables by providing a small form factor, low cost wireless solution that will link computers, cell phones, and other electronics. Bluetooth also allows users to connect many ranges of devices fast and easily and expands communications capabilities as well.

The size of the Bluetooth radio is extraordinary, as a Bluetooth radio can be built into one or two very small microchips then integrated into any electronic device where wireless operations would be an advantage. Bluetooth also offers a robust link, which ensures that normal operating circumstances are not interrupted by interference from other signals that are operating in the same frequency band. Also known for its worldwide operation, Bluetooth radio operates in the 2.4 GHz frequency band, which is license free and attainable to any type of radio system in the world. No matter where you are in the world, you count on Bluetooth to work. Security is also important. Offering advanced security mechanisms, Bluetooth ensures a high level of security. Therefore, authentification will prevent unauthorized access to important data and make it very difficult listen in. Bluetooth also boasts power optimization. The radio is power friendly and the software for Bluetooth is very configurable, limiting the power consumption of equipment. The radio itself only consumes a small amount of power from a cellular phone.

4.4 Disadvantages

One of the main disadvantages is that Bluetooth operates on small bandwidth of about 721kb, and has a maximum range of roughly 30ft.There is also limited voice compatibility Bluetooth is that it uses the same frequency as the Wavelan standard. Another problem for Bluetooth is when there are a number of mobile devices in the same room, and possibly attempting the same operation. Since Bluetooth is omni-directional, it encounters problems in discovering the intended recipient device. Bluetooth devices must perform a discovery operation that will likely find many other devices in the same room. At this point, the user must choose the proposed recipient, which will require special information. Furthermore, Bluetooth has so many security mechanisms that it would have to carry out in order to prevent eavesdropping.

5. Conclusion

In this paper, we presented an overview of wireless communication that is transfer of information without use of wires. 4G is based entirely on packet switched networks. In addition, all 4G networks will be digital and will provide higher bandwidths of up to 100Mbps. Bluetooth was the creation of a single digital wireless protocol, capable of connecting multiple devices and overcoming problems arising from synchronization of these devices. Wi-Fi technology is gaining acceptance as an alternative to a wired LAN.

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