CHAPTER ONE

Mobile Computing Overview

1.1 Introduction

Mobile computing systems are computing systems that may be easily moved physically and whose computing capabilities may be used while they are being moved. Examples are laptops, personal digital assistants (PDAs), and mobile phones.

By distinguishing mobile computing systems from other computing systems we can identify the distinctions in the tasks that they are designed to perform, the way that they are designed, and the way in which they are operated. There are many things that a mobile computing system can do that astationary computing system cannot do; these added functionalities are the reason for separately characterizing mobile computing systems. Among the distinguishing aspects of mobile computing systems are

- Their prevalent wireless network connectivity,
- Their small size,
- The mobile nature of their use,
- Their power sources,and
- Their functionalities that are particularly suited to the mobile user.

Because of these features, mobile computing applications are inherently different than applications written for use on stationary computing systems.

1.2 : A Brief History of Mobile Computing

Figure 1.1 shows a timeline of mobile computing development.

- One of the very first computing machines, the abacus, which was used as far back as 500 B.C., was, in effect, a mobile computing system because of its small size and portability.

- The first mobile storage systems can be traced back only as far as the advent of the age of electronics.Amobile computing system,as with any other type of computing system, can be connected to a network. Connectivity to the network, however, is not aprerequisite for being a mobile computing system.

- Dating from the late 1960s, networking allowed computers to talk to each other. Networking two or more computers together requires some medium that allows the signals to be exchanged among them.
- By the 1960s, the military had been using various forms of wireless communications for years. Not only were wireless technologies used in a variety of voice communication systems,but the aviation and the space program had created great advances in wireless communication as well.
- By the 1970s, communication satellites began to be commercialized. With the new communication satellites, the quality of service and reliability improved enormously. Still, satellites are expensive to build, launch, and maintain. So the available bandwidth provided by a series of satellites was limited.
- In the 1980s cellular telephony technologies became commercially viable.
- the 1990s were witness to advances in cellular technologies that made wireless data communication financially feasible in a pervasive way.

- Because the greatest advances in mobile communications originated in the military, it is no surprise that one of the first applications of wireless communication for mobile computing systems was in displaying terrain maps of the battlefield. From this, the global positioning system (GPS) evolved so that soldiers could know their location satany given time. Portable military computers were provided to provide calculations, graphics, and other data in the field of battle.

In recent years, wireless telephony has become the major provider of a revenue stream that is being invested into improving the infrastructure to support higher bandwidth data communications.

1.3

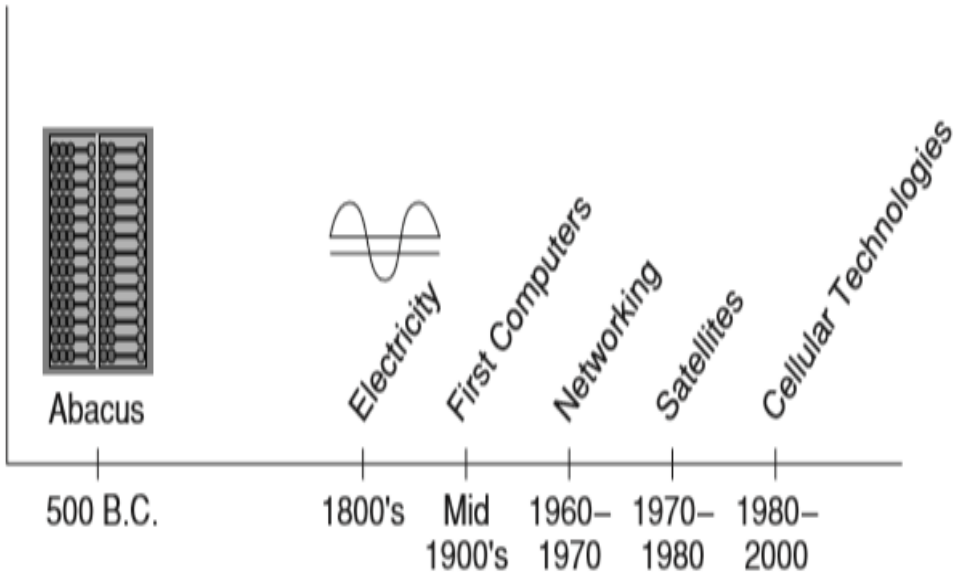


FIGURE 1.1. A Timeline of Mobile Computing.

1.3 Definition of Mobile Computing

The rapidly expanding technology of cellular communication, wireless LANs, and satellite services will make information accessible anywhere and at any time. Regardless of size, most mobile computers will be equipped with a wireless connection to the fixed part of the network, and, perhaps, to other mobile computers. The resulting computing environment, which is often referred to as mobile or nomadic computing, no longer requires users to maintain a fixed and universally known position in the network and enables almost unrestricted mobility. Mobility and portability will create an entire new class of applications and, possibly, new massive markets combining personal computing and consumer electronics.

A technology that allows transmission of data, via a computer, without having to be connected to a fixed physical link.

- Mobile voice communication is widely established throughout the world and has had a very rapid increase in the number of subscribers to the various cellular

networks over the last few years. An extension of this technology is the ability to send and receive data across these cellular networks. This is the principle of mobile computing.

- Mobile data communication has become a very important and rapidly evolving technology as it allows users to transmit data from remote locations to other remote or fixed locations.

Mobile Computing is an umbrella term used to describe technologies that enable people to access network services anyplace, anytime, and anywhere.

There are 2 aspects of mobile computing

- **User mobility:** users communicate "anytime, anywhere, with anyone" (example: read/write email on web browser). User mobility refers to a user who has access to the same or similar telecommunication services at different places, i.e.,the user can be mobile, and the services will follow him or her.
- **Device portability:** devices can be connected anytime, anywhere to the network. With device portability, the communication device moves .Many mechanisms in the network and inside the device have to make sure that communication is still possible while the device is moving.

1.4 Applications Of Mobile Computing

In many fields of work, the ability to keep on the move is vital in order to utilize time efficiently. The importance of Mobile Computers has been highlighted in many fields of which a few are described below:

1. Online delivery systems associated with credit card verification.
2. Taxi/cab services operated via smartphones and mobile apps.
3. Location-aware mobile services used to transmit weather and road conditions.
4. Social media applications and e-mail access via smartphones.
5. Smart wearable devices which are used to measure and record medical/health conditions of individuals.

1.5 Principles of Mobile Computing

The following factors have been identified as the Principles of Mobile Computing.

1. **Portability**

   Devices/nodes connected within the mobile computing system should facilitate mobility. These devices may have limited device capabilities and limited power supply, but should have a sufficient processing capability and physical portability to operate in a movable environment.

2. **Connectivity**

   This defines the Quality of Service (QoS) of the network connectivity. In a mobile computing system, the network availability is expected to be maintained at a high level with the minimal amount of lag/downtime without being affected by the mobility of the connected nodes.

3. **Interactivity**

   The nodes belonging to a mobile computing system are connected with one another to communicate and collaborate through active transactions of data.

4. **Individuality**

   A portable device or a mobile node connected to a mobile network often denote an individual; a mobile computing system should be able to adopt the technology to cater the individual needs and also to obtain contextual information of each node.

1.6 Characteristics of mobile computing environment

1. User mobility: user accesses the service while on move.
2. Network mobility
   - User moves from one network to another accessing the service seamlessly.
   - Network itself is mobile as in MANET (Mobile AD-hoc Networks).
3. Beaer Mobility: User uses the same service while switching the bearer.

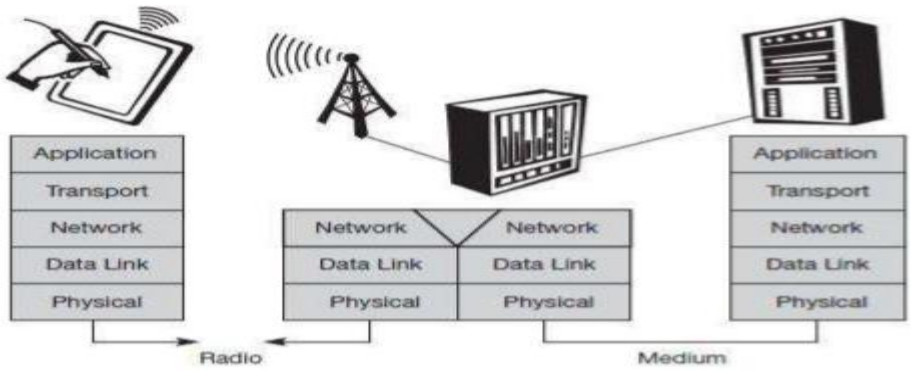
4. Device Mobility:User use the same service while switching from one device to other.
5. Session Mobility:User session shold able to move from one user- agent environment to other.
6. Host Mobility: User device can be server or host.
7. Agent Mobility : User –agent (browser,crawlers)or the application move from node to other.

1.7 LIMITATIONS OF MOBILE COMPUTING

8. Resource constraints: Battery.
9. Interference: Radio transmission cannot be protected against interference using shielding and result in higher loss rates for transmitted data or higher bit error rates respectively.
10. Bandwidth: Although they are continuously increasing, transmission rates are still very low for wireless devices compared to desktop systems. Researchers look for more efficient communication protocols with low overhead.
11. Dynamic changes in communication environment: variations in signal power within a region, thus link delays and connection losses.
12. Network Issues: discovery of the connection-service to destination and connection stability.
13. Interoperability issues: the varying protocol standards.
14. Security constraints: Not only can portable devices be stolen more easily, but the radio interface is also prone to the dangers of eavesdropping. Wireless access must always include encryption, authentication, and other security mechanisms that must be efficient and simple to use.

1.8 A SIMPLIFIED REFERENCE MODEL

The Figure shows a personal digital assistant (PDA) which provides an example for a wireless and portable device. This PDA communicates with a base station in the middle of the picture. The base station consists of a radio transceiver (sender and receiver) and an interworking unit connecting the wireless link with the fixed link. The communication partner of the PDA, a conventional computer, is shown on the right-hand side.The figure shows the protocol stack implemented in the system according to the reference model. End-systems, such as the PDA and computer in the example, need a full protocol stack comprising the application layer, transport layer, network layer, data link layer, and physical layer. Applications on the end-systems communicate with each other using the lower layer services. Intermediate systems, such as the interworking unit, do not necessarily need all of the layers. As (according to the basic reference model) only entities at the same level communicate with each other (i.e., transport with transport, network with network) the endsystem applications do not notice the intermediate system directly in this scenario. The following paragraphs explain the functions of each layer in more detail in a wireless and mobile environment.



● **Physical layer:** This is the lowest layer in a communication system and is responsible for the conversion of a stream of bits into signals that can be transmitted on the sender side. The physical layer of the receiver then transforms the signals back into a bit stream. For wireless communication, the physical layer is responsible for frequency selection, generation of the carrier frequency, signal detection (although heavy interference may disturb the signal),

modulation of data onto a carrier frequency and (depending on the transmission scheme) encryption.

● **Data link layer:** The main tasks of this layer include accessing the medium, multiplexing of different data streams, correction of transmission errors, and synchronization (i.e., detection of a data frame). Altogether, the data link layer is responsible for a reliable point-topoint connection between two devices or a point-to-multipoint connection between one sender and several receivers.

● **Network layer:** This third layer is responsible for routing packets through a network or establishing a connection between two entities over many other intermediate systems. Important functions are addressing, routing, device location, and handover between different networks.

Transport layer: This layer is used in the reference model to establish an end-to-end connection. Quality of service, flow and congestion control are relevant, especially if the transport protocols known from the Internet, TCP and UDP, are to be used over a wireless link.

● **Application layer:** Finally, the applications (complemented by additional layers that can support applications) are situated on top of all transmission oriented layers. Functions are service location, support for multimedia applications, adaptive applications that can handle the large variations in transmission characteristics, and wireless access to the world-wide web using a portable device.

1.9 MOBILE COMPUTING Vs WIRELESS NETWORKING

The terms "mobile" and "wireless" are often used interchangeably but in reality, they are two very different concepts applied to modern computing and technology.

Mobile is a word that is commonly used to describe portable devices. A mobile device is one that is made to be taken anywhere. Therefore, it needs an internal battery for power,

and must be connected to a modern mobile network that can help it to send and receive data without attaching to a hardware infrastructure.

Wireless, on the other hand, does not mean mobile. Traditional computers or other non-mobile devices can access wireless networks. One very common example is the use of a localized browser product in a local area network (LAN), where the router takes what used to be a cabled interaction and makes it wireless. Other kinds of wireless networks called wide area networks (WAN) can even use components of 3G or 4G wireless systems made specifically for mobile devices, but that doesn‘t mean that the devices on these networks are mobile. They may still be plugged in or require proximity to a router or network node.

Mobile and wireless systems really accomplish two very different things. While a wireless system provides a fixed or portable end point with access to a distributed network, a mobile system offers all of the resources of that distributed network to something that can go anywhere, barring any issues with local reception or technical area coverage.

For another example of the difference between mobile and wireless, think of businesses that offer Wi-Fi hotspots. A Wi-Fi hotspot is typically a resource for someone who has a relatively fixed device, such as a laptop computer that doesn‘t have its own internal Internet access built in. By contrast, mobile devices already have inherent access to the Internet or other wireless systems through those cell tower networks that ISPs and telecom companies built specifically for them. So mobile devices don‘t need Wi-Fi - they already have their connections.

To some who are used to using both wireless and mobile networks, this distinction may seem very simple. However, the difference between providing mobile and wireless is likely to be something that gets explored more as new technologies continue to develop, and companies continue to offer more different kinds of interfaces to consumers.

Mobile is subgroup from wireless. We have wireless systems that are not mobile and we have technologies which are wireless but not mobile in sense of technologies deployed in mobile operators networks. We have fixed wireless (e.g. fixed WiMAX) and e.g. TETRA which is not technology deployed in mobile (operators) networks.

In communication engineering, wireless communication(both static and dynamic) is communication between Nodes/system without use of direct physical connection rather it is through a non conducting or dielectric media. Where as in mobile communication, communicating nodes moves within specified area and method of communication is wireless communication suitably..e.g.-Mobile Ad-hoc networks (MANETs).

Wireless Communication in itself is a very broad concept that is achieved using various inter-related technologies. Mobile Communication utilizes some of the technologies that are made available / possible by Wireless Communication. Some of the popular wireless technologies employed in Mobile Communication include: GPRS (General Packet Radio Service), LTE (Long Term Evolution), HSPA (High Speed Packet Access), GSM (Global System for Mobile Communication), EDGE (Enhanced Data GSM Environment), CDMA (Code Division Multiple Access) and its variants, etc.

Wireless refers to the method of transferring information between a computing device, such as a personal data assistant (PDA), and a data source, such as an agency database server, without a physical connection. However, not all wireless communications technologies are created equally, offer the same uses or are even mobile.

Mobile computing refers to computing devices that are not restricted to a desktop. A mobile device may be a PDA, a smart phone or a web phone, a laptop computer, or any one of numerous other devices that allow the user to complete tasks without being tethered, or connected, to a network. Mobile computing does not necessarily require wireless communication. In fact, it may not require communication between devices at all.

Wireless communication is simply data communication without the use of a landline. This may involve a cellular telephone, a two way radio, a fixed wireless connection, a laser, or satellite communications. Here the computing device is continuously connected to the base network.

Mobile computing essentially refers to a device that is not always connected to a central network. This group of devices includes laptops, newly created smart phones and also PDA's. These products may communicate with a base location, with or without, a wireless connection

1.10 ADDED DIMENSIONS OF MOBILE COMPUTING

It should be obvious that any mobile computing system can also be stationary! If we stop moving it, it is stationary. So, we can say that mobile computing systems are a super set of stationary computing systems .Therefore; we need to look at those elements that are outside of the stationary computing subset. These added dimensions will help us pick out variables that in turn allow us to divide and conquer the problems of mobile computing. The dimensions of mobility, as we will refer to them in this text, will be the tools that allow us to qualify our problem of building mobile software applications and mobile computing systems. Although these dimensions of mobility are not completely orthogonal with respect to each other, they are separate enough in nature that we can distinguish them and approximate them as orthogonal variables. Also, keep in mind that some of these dimensions are limitations; nevertheless, they are still added dimensions that need not be considered when dealing with the typical stationary application. These dimensions of mobility (Figure 1.3) are as follows:

1. Location Awareness,
2. Network Connectivity Quality Of Service (Qos),
3. Limited Device Capabilities (Particularly Storage And Cpu),
4. Limited Power Supply,
5. Support For A Wide Variety Of User Interfaces,
6. Platform Proliferation
7. Active Transactions.

It is absolutely crucial that the reader understands these dimensions of mobility and keeps them in mind throughout the process of design and implementation of the mobile application. Too often, engineers begin with attention to design and get bogged down in details of the tools that they use and small focused problems within the bigger picture of the system, its design, and its architecture. The definition of the word “mobile” reveals the first dimension we will consider: location.

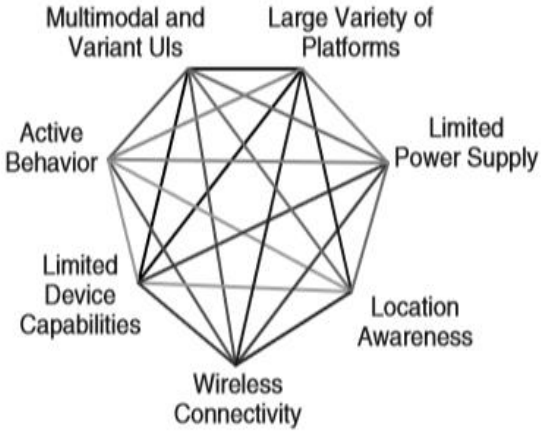


FIGURE 1.3. Dimensions of Mobility.

1.11 Different types of Mobile Systems

In many ways, mobile computing has several characteristics reminiscent of distributed systems. In order to understand mobile systems, one must first understand where the similarities and the differences of distributed and mobile systems lie. The following section is an explanation of the different types of distributed systems ranging from the traditional type to nomadic, ad-hoc and finally ubiquitous ones.

1. Traditional Distributed System

Traditional distributed systems consist of a collection of fixed hosts that are themselves attached to a network– if hosts are disconnected from the network this is considered to be abnormal whereas in a mobile system this is quite the norm. These hosts are fixed and are usually very powerful machines with fast processors and large amount of memory. The bandwidth in traditional systems is very high too.

Furthermore, the execution context is said to be static as opposed to a dynamic context whereby host join and leave the network frequently. In a traditional system, location rarely changes as well and hosts are much less likely to be added or deleted from the network.

Traditional distributed systems also need to guarantee non-functional requirements3 such as scalability (accommodate a higher load at some time in the future), openness (possibility to extend and modify the system easily), heterogeneity (integration of components written using different programming languages, running on different operating systems, executing on different hardware platforms), fault-tolerance (recover from faults without halting the whole system) and finally resource-sharing (some form of access control).

2. Nomadic Distributed System

This kind of system is composed of a set of mobile devices and a core infrastructure with fixed and wired nodes. Mobile devices move from location to location, while maintaining a connection to the fixed network. There are problems that arise from such shifts in location. The mobile host has a home IP address and thus any packets sent to the mobile host will be delivered to the home network and not the foreign network where the mobile host is currently located. Such problem can be solved by forwarding packets to the foreign network with the help of Mobile IP. Nevertheless, Mobile IP also suffers from efficiency (routing issues), QoS, security (authentication of mobile host at foreign network and end-to-end security required) and wireless access (reduced capacity) problems.

These systems are susceptible to the uncertainty of location, a repeated lack of connections and the migration into different physical and logical environments while operating. However, compared to ad-hoc networks, nomadic systems still have comparatively reliable connections and services since most of these are actually supported by the fixed infrastructure (“backbone”) of the network.

The non-functional requirements mainly differ, compared to the traditional distributed systems, in the heterogeneity (affected by the presence of both fixed and mobile devices across the network as well as the variations in technologies (e.g.: wireless)), resource sharing (must take into account different issues when the resources need to be discovered) and fault tolerance of the system (considered to be quite the norm). Quality and provision of these resources must be carefully considered too.

3. Ad-Hoc Mobile Distributed System

Ad-hoc distributed systems are possibly the only type of network that comes close to mobile networks in the sense that every node is literally mobile. It is these networks that are very much seen as the systems of the future, whereby hosts are connected to the network through high-variable quality links (e.g.: from GPS to broadband connection) and executed in an extremely dynamic environment.

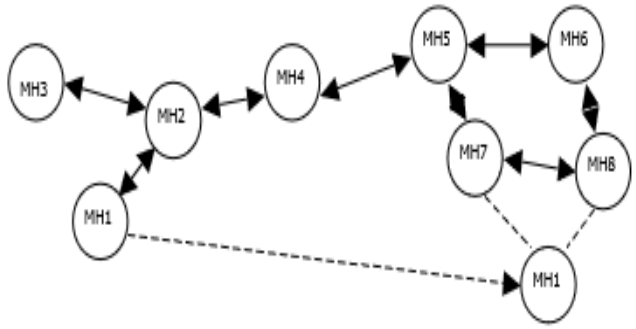
A-hoc systems do not have any fixed infrastructure which differs them both from traditional and nomadic distributed systems. In fact, ad-hoc networks may come together as needed, not necessarily with any assistance from the existing (e.g.: Internet) infrastructure. When nodes are detached from the fixed/mobile network they may evolve independently and groups of hosts opportunistically form “clusters” of mini-networks. The speed and ease of deployment make ad-hoc networks highly desirable.

These kinds of systems are extremely useful in conditions where the infrastructure is absent, impractical to establish or even expensive to build (e.g.: military applications, high terrain uses, and emergency relief operations).

However, being a relatively new technology, this field of networking demands a lot of research to be done to improve it, especially its non-functional requirements as well as algorithms for routing protocols (e.g.: distance vector and dynamic source routing algorithms).

Security threats have to be dealt even more cautiously in ad-hoc networks. Designing secure key distribution in an ad-hoc network might be an extremely hard task. Any reliance on a certificate of authority is not trivial at all, for the same reasons that reliance in any centralized authority is problematic. Additional problems include the increased packet sizes required by authentication extensions, unicast/multicast routing, Quality of Service support and power aware routing. Furthermore, due to the limited transmission range of wireless network interfaces, multiple hops may be needed to exchange data between nodes in the network (c.f. MANET).

Ad Hoc network of mobile nodes – these are able to move relative to each other. MH1 moves away from MH2 and establishes new links with MH7 and MH8. Most algorithms also allow for the appearance of new mobile nodes and the disappearance of previously available nodes.

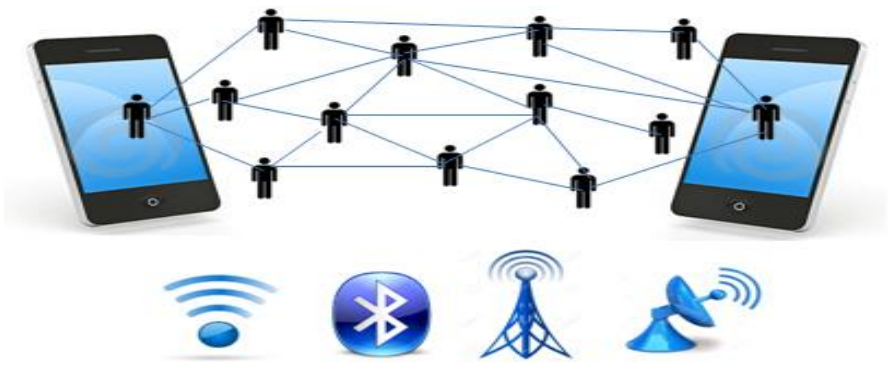


1.12 Main Components of a Mobile Computing System

A mobile computing system consists of the following components.

1. Mobile Communication

Mobile Communication refers to the exchange of data and voice using existing wireless networks. The data being transferred are the applications including File Transfer (FT), the interconnection between Wide-Area-Networks (WAN), facsimile (fax), electronic mail, access to the internet and the World Wide Web. The wireless networks utilized in communication are IR, Bluetooth, W-LANs, Cellular, W-Packet Data networks and satellite communication system. It is the mobile communication infrastructure which takes care of seamless and reliable communication between mobile devices.



2. Mobile Hardware

Mobile Hardware is a small and portable computing device with the ability to retrieve and process data. Smartphones, handheld and wearable devices fall under mobile hardware. These devices typically have an Operating System (OS) embedded in them and able to run application software on top of it. These devices are equipped with sensors, full-duplex data transmission and have the ability to operate on wireless networks such as IR, WiFi, and Bluetooth.

3. Mobile Software

Mobile Software is the software program which is developed specifically to be run on mobile hardware. This is usually the operating system in mobile devices. These operating systems provide features such as touchscreen, cellular connectivity, Bluetooth, Wi-Fi, GPS mobile navigation, camera, video camera, speech recognition, voice recorder, music player, near field communication and sensors. The device sensors and other hardware components can be accessed via the OS.