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Transparent Computing: A Primer

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Abstract Transparent computing is an emerging technology that allows users to enjoy user-controlled services by extending the stored program concept in the von Neumann architecture spatio-temporally into networking environments. It is considered a form of persuasive computing and is a characteristic of pervasive computing. It aims to provide a cross-platform user experience in a hassle-free way, and make computer systems more secure, more reliable, and more flexible. It may be regarded as the latest realization of ubiquitous computing. This paper provides a brief introduction to transparent computing.

Keywords transparent computing, ubiquitous computing, pervasive computing

Introduction

The traditional computing systems have several problems including [1]: (1) Modern computing systems are complex and opaque; (2) The total cost of ownership (TCO), including hardware and software cost, is increasing high; (3) Weak security including malicious attacks, as viruses, information leakage, and data theft; (4) Not user-friendly, users cannot get services from computer hassle free. Pervasive computing promises a computing environment that ubiquitously supports users in accomplishing their tasks in a way that the actual computing devices and technologies are largely invisible.

Transparent computing (TC) is an implementation of ubiquitous/pervasive computing that is aimed at providing active services for users. This implies that users do not need to be aware of the details of the underlying technology; they only have to be concerned about the services they need [2]. TC involves systems that could, for example, solve various user problems without any knowledge on the part of the user of what is happening. In this regard, transparent means invisible. Devices are invisible or transparent in the sense that they operate without the conscious interaction of the user. Virtually all man-made elements will feature transparent computing abilities.

Transparent computing may also be regarded as a special kind of cloud computing that provides software storage as a service, a special kind of Infrastructure-as-a-Service (IaaS). Cloud computing enables users to get their desired services anytime, anywhere, and by any means. Cloud computing mainly focuses on providing services through servers and networks without addressing the concerns of user terminals, such as energy efficiency, security, and cross-platform compatibility. Consequently, these challenges remain in the era of cloud computing and big data. A new computing paradigm, known as transparent computing, solves this problem partially. Just like cloud computing, transparent computing stores software and user data at specific servers. As shown in Figure 1, transparent computing extends the bus transmission found in traditional computer architectures [3]. TC is user-controlled cloud computing, where the users can run the desired applications on different operating systems with different devices. Cloud computing solves the issue of data cloudlization, while

transparent computing solves the one of software cloudlization. While in cloud computing, both data storage and computing are performed on servers, in transparent computing, data storage takes place on servers, but data computing takes place on user terminals. Just like cloud computing, transparent computing stores software and user data at specific servers.

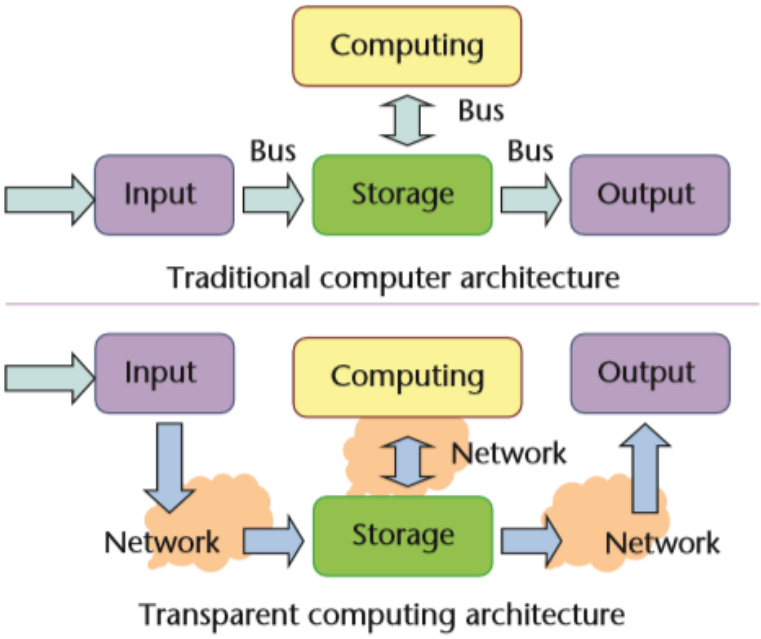

Figure 1: Transparent computing extends the bus transmission found in traditional computer architectures [3]

Concept of Transparent Computing

The main goal of transparent computing is to make currently opaque computing systems transparent by providing high-fidelity visibility into component interactions during system operation. The transparent computing paradigm aims at meeting user demands for any computing services in a trouble-free way in the right place at the right time.

Professor Yaoxue Zhang introduced the concept of transparent computing in 2006. Transparent computing is a major shift in approach from traditional computing schemes. It is a new kind of pervasive computing that works in a client-server mode (just like cloud computing) with the architecture composed of transparent client and server machine, as shown in Figure 2 [4]. In other words, a transparent computing-based system consists of a network server and one or more client terminal. TC emphasizes data storage at the server side, and computing at the client side. The client can be desktop computers, PDA, digital embedded appliances or mobile devices. Programs are stored on the servers as opposed to local storage devices as in traditional computers. Transparent computing separates computation from storage.

The transparent computing paradigm consists of transparent clients, transparent network, and transparent server. The technologies that enable TC include software interoperability standards, virtualization technologies, high-bandwidth communications, and Web 2.0

It has the following features [5]:

- Separate computing and storage
- Compatibility with different operating systems
- Reduction of different hardware and software compatibilities
- Potential of centrally managed data and information
- Considerable time savings, as the whole process is converted into one that is seamless
- Distributed deployment of services
- Dynamic scheduling and execution of applications
- Better protection of data, which is centrally managed, creating comparatively fewer leakages than other paradigms

- Reduced complexities and other costs
- Significant tackling of privacy and security issues

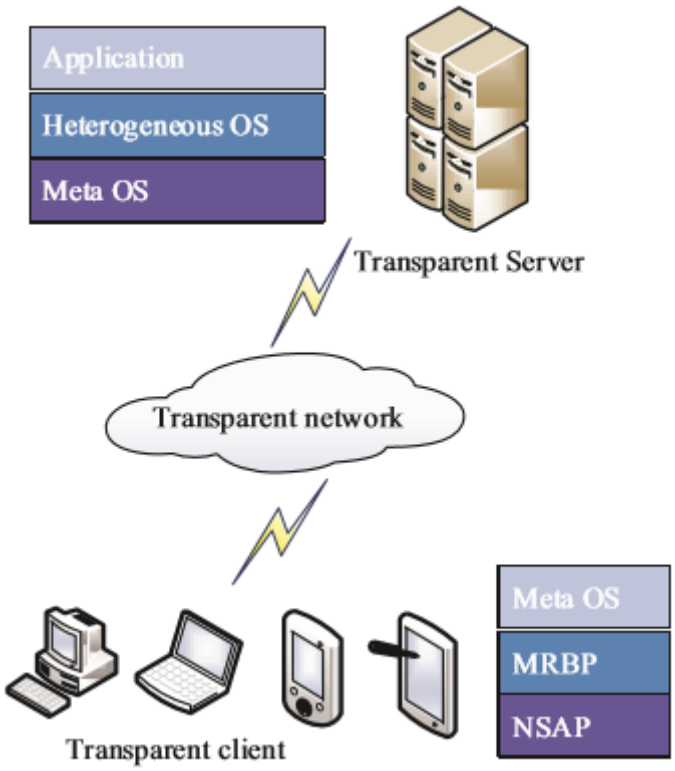

Figure 2: Transparent computing architecture [4]

Applications

Transparent computing has attracted both academic and industry attention, with numerous applications and products already been produced. It has been used successfully in building service-oriented platforms and has also shown its potential in many applications. The following are common applications of TC.

- *Mobile Transparent Computing:* Applying transparent computing concept to mobile devices (such as smartphone and tablet) leads to mobile transparent computing. In other words, mobile transparent computing is a combination of transparent computing and mobile computing. Mobile transparent computing generally uses the wireless local area network (WLAN) or 3G network. In mobile transparent computing, the client terminal is rather light weighted, while the operating systems are stored in the server as software resources. The framework of mobile transparent computing in show in Figure 3 [6].
- *MANETs:* Transparent computing devices may be deployed in mobile ad hoc networks (MANETs). Portable or wearable devices may be deployed in a mobile ad hoc network (MANET) to share data or resources.
- *IoT Platforms:* The fast-growing IoT technology faces some challenges posed by large-scale heterogeneous IoT devices. How to manage and maintain these devices and resources becomes a significant challenge for IoT applications. These challenges can be addressed by employing transparent computing based IoT architecture to build scalable and manageable IoT applications. In transparent computing, operating systems, applications, supporting tools, and user data are regarded as resources, which can be centrally managed [7]. Transparent computing has the potential to provision scalable services at the edge for lightweight IoT devices.

Other applications of TC include transparent grid computing.

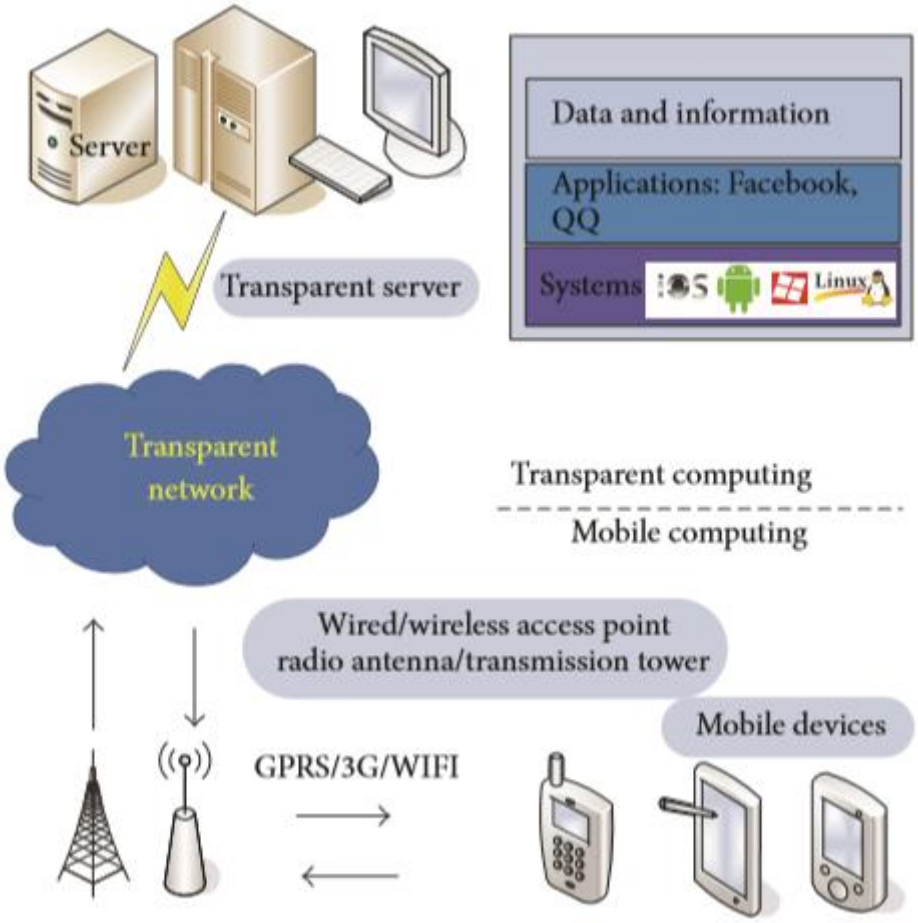

Figure 3: Framework of MTC [6]

Benefits and Challenges

Besides the same benefits as cloud computing (such as improved operational efficiency, flexibility, and reliability), transparent computing has the following benefits [3]: (1) It reduces terminals' complexity and cost; (2) It improves the user experience; (3) It offers a high level of security; and (4) It offers cross-platform capability. In addition, TC have the following beneficial features [1]: (1) User and application transparency, (2) Heterogeneous support for operating systems, (3) Streaming delivery, (4) Support of various devices, (5) Enhanced security. TC is a computing model in which users can find relevant computing services from a variety of devices in distributed network, according to their needs and without knowing the storage.

In spite of the benefits of transparent computing offers, it also brings new challenges to service reliability, privacy, and security: operating systems, applications, and data are centralized on servers and shared by all users. It is vulnerable to some traditional security risks such as privileged user access, viruses, malicious attack, and data theft.

Conclusion

Transparent computing is an emerging computing paradigm where the users can enjoy any kind of service over networks on-demand with any devices. It spatio-temporally extends the von Neumann architecture from the concept of "stored program" to the networking environments. It is a new computing paradigm for service sharing.

Although transparent computing is still an emerging idea, it is a forward-looking approach to what future computing environments could look like. More information about TC can be found in books [1,8].

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