A Framework for Mobile Collaboration-Heading Towards Unified Communications

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Abstract
This paper constitutes an organized summary of literature about mobile collaboration, the use of information and communication technologies to support coordination between users who are moving about. The emphasis is on integration of views concerning information technology, and people. This paper also describes MoCA. MoCA the Mobile Collaboration Architecture is a middleware technology for developing and deploying context-aware collaborative applications for mobile users. It comprises of client and server APIs, core services for monitoring and logically gathering the mobile devices, context, and an object-oriented framework for instantiating customized application proxies. It also aims to describe the design and implementation framework for developing collaborative applications on mobile phones. Central concepts such as PAN networks, Mobile Ad Hoc Networks (MANET) and CSCW are also illustrated relating to the collaborating devices to present an inclusive picture of the research domain to capture the right design decisions.

Keywords
MoCA, Context Information Service MANET, Computer Supported Cooperative Work, Unified Communication.

I. Introduction
In the past 20 years, the influence of computers on our lives has risen immensely. Our use of computers have gone from non-connected standalone applications, to being used for collaborative work where in several users can contribute to work processes without being collocated, both physically and time-wise. The recent years have revealed a tendency where computers have become more portable to fit the needs of users. This tendency has further been strengthened by the growth in the mobile phones user base in tandem with the increasing computational capacity of the mobile phones. Today, mobile phones have the same computational capacity of the late 80's with one important addition i.e. accessibility and power. Mobile phones are constantly connected to a network, making them available for collaborative work anywhere and anytime. The use of handheld and other portable devices in collaboration is not a new idea, but is still a quite immature research field. Researchers have faced many problems in the research conducted on Computer Supported Cooperative Work (CSCW) using full scale computers [1]. The same difficulties will be present on more limited portable devices, but the portable devices can draw benefits from aspects such as mobility and making them more suitable for usage in certain areas of CSCW. Although having limited capacity, the mobile phones have a quite clear advantage over the traditional stationary computers and even laptop computers [4]. Mobile phones are mobile to an extreme degree, providing us omnipresent computational devices. When using a mobile phone for collaborative applications, it is always available to be used in the collaborative process. Mobile technologies are becoming increasingly popular in travel, education, stock trading, military, and medical emergency care etc. As organizations begin to rely on mobile technologies, at the same time, they are also increasing their reliance on the use of groups to accomplish key organizational tasks.

A. Collaboration.
When an activity is to be carried out by more than one individual, issues related to communication and synchronization emerges [1]. This effort can be viewed as a collaborative effort to reach a common goal or share an experience. Human collaboration is a very complex natural system that we do not fully understand today. This vast complexity is due to many contributing factors such as:

1. Explicit Communication
Person-to-person communication is a thoroughly researched field but still a field we do not completely understand.

2. Contextual communication
Much of the information exchanged between the participants in a collaborative activity is of the informal type. This includes gestures, body language, ambiguity in the verbal communication due to the use of irony or sarcasm etc.

3. Environment
Often the participants uses the environment for communicating, e.g. the use of prop when trying to explain a model or example. This complexity is further expanded by the use of spontaneous and highly unstructured communication paths.

B. Types of Collaboration

1. Synchronous Collaboration
A computer-mediated interaction between two or more people that occurs within 5 seconds (i.e. an instant message)

2. Asynchronous Collaboration
No time interaction limit (e.g. an email)

3. Semi-synchronous Collaboration
Interaction with intervals longer than 5 seconds but within some prescribed time frame.

C. Mobile Collaboration
Collaboration can be defined as an interaction between two or more people accomplishing particular task [2]. Mobile Collaboration is a process of communicating using electronic assets and accompanying software designed for use in remote locations as shown in Figure1. Newest generation hand-held electronic devices deal with video, audio, and telestration (on-screen drawing) capabilities and broadcast over secure networks, enabling multi-party conferencing in real time.

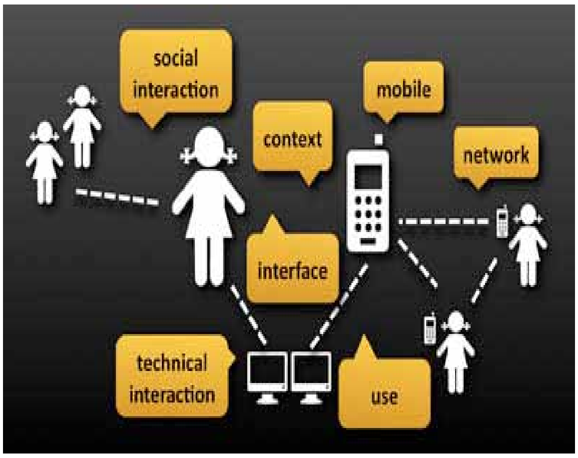

Fig.1: Mobile collaboration

Collaboration using mobile devices can take place at several different levels. At the lowest level, collaboration simply means being able to access e-mail or instant messages from colleagues and send replies. Often, this requires software to coordinate a company's servers with various mobile devices that employees take with them when they are roaming. The second level of collaboration using mobile technologies is to enable people to meet while some or all of the participants are on the road. The easiest way to achieve this is through a conference call involving all participants. It can also be achieved through laptop or mobile phone connections with high-speed WiFi networks. A third level is to use online meeting software that is specifically designed to include mobile devices. Vendors now offer products that will support mobile collaboration at all these levels. Unified communication and collaboration (UCC) is a concept promoted by many different vendors although it is relatively expensive to set up. Mobile end points are becoming more capable. They are smarter and have more storage, and allow you to have a window into your desktop information from anywhere. With more cell phones in the world than PCs (even laptops), it is no wonder that software vendors have seen this platform become a higher priority as an end-point and a way for mobile information workers to collaborate with their colleagues and team members. As the components continue to shrink and wireless network technologies become more sophisticated and less expensive, these handhelds will expand on the capabilities we already see now in the market place for example: voice, pictures, video/broadcast, e-mail, and full Internet access etc. Cell phones are already a growing platform for Internet access. However, as off now a low percentage of cell phone users access data through their devices. A recent Pew Internet and American Life study found that only "10% rely on mobile devices for voice, texting, or entertainment." That number will undoubtedly jump dramatically in the next two to five years, due to both technical and non-technical factors and the obvious advantages of a highly mobile platform. These factors include low cost, ease of maintenance, well-established providers, manageable form factor, over-the-air upgrades, power management, and other characteristics that support this platform for growth. The implications for teamwork are clear, if workers can take lightweight devices with them anywhere; access materials and discussions on a team space, communicate with audio, video, text, and data transmissions, they will be even freer and more pertinent to work from wherever and whenever they can.

II. Mobile Collaboration Architecture

MoCA is a middleware architecture that supports the development and deployment of context-aware distributed applications for infra-structured wireless local networks i.e. IEEE 802.11b/g WLANs. It provides a means for collecting, storing and processing context data from mobile devices (notebooks for instance). Essentially, MoCA consists of a set of API's that enable easier and more effective application development by providing easy access to generic services useful for a variety of applications. It does not assume any specific architecture for the application (i.e. client/server or P2P). However, it requires that the mobile devices have IEEE 802.11 interfaces, and are able to connect to IEEE 802.11 access points, i.e. that the user has the proper authorization. MoCA also comprises a set of core services that support the execution of context aware applications. Now it can be used only for portable devices running Windows XP. The Windows CE version is under development.

A. Architecture

A MoCA-based application must be developed using the MoCA Client API. If the application has client/server architecture [3], it may use the MoCA Server API. These APIs conceal from the programmer many of the details of using the MoCA core services. While the MoCA client generally runs in a mobile host, the server typically runs on the wired network. The MoCA architecture is shown in Fig. 2.

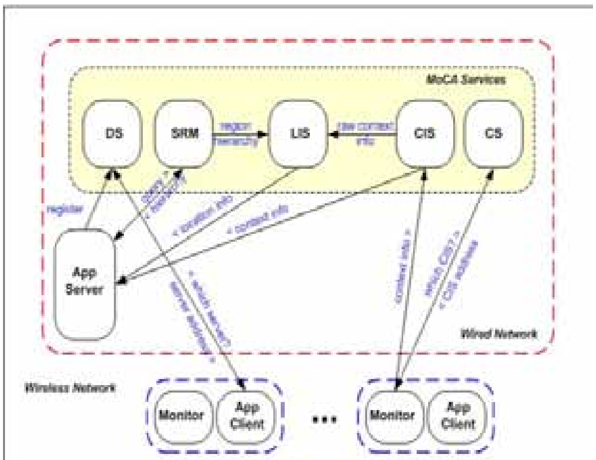

Figure2: MoCA Architecture

The Client-API, when executed, automatically starts the MoCA Monitor, a daemon that runs on each mobile device and is accountable for collecting data about the device's execution state and environment [4], i.e. the device's context information, which may include the wireless connection's quality, energy usage level, CPU usage, free memory, current access point (AP), and a list of all APs and their signal strengths that are within the mobile device's range. All the collected data is sent to a specific MoCA service named Context Information Service (CIS). The CIS [5] is a distributed service where each CIS server, typically running on a node of the wired network, receives, stores and processes the context information sent by a set of monitors, each running in a particular mobile device. It also receives requests for notifications (i.e. subscriptions) from application clients and servers and generates and delivers events to the subscriber applications whenever a change in a device's state is of their interest. Both the ClientAPI and ServerAPI provide means of accessing the data about any device being monitored stored by the CIS server. The configuration service(CS) stores and manages configuration information about each mobile device so that they can use the CIS service. The CS stores this information in a persistent hash table, where each entry is indexed by the mobile device's media access control address (MAC address) holds the corresponding

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CIS server's address (IP and port), and the periodicity according which the monitor must send the device's information to the CIS. The MAC address specific indexing is essential for implementing a distributed CIS, where each server gets approximately the same context processing load. The Location Inference Service (LIS) is responsible for gathering the approximate location of a mobile device from the raw context information collected by the CIS for a given device. It compares the device's current pattern of RF signals received with the signal patterns previously measured at predefined reference points in a building or open area. Therefore, before being able to make any inference, the LIS database has to be populated with RF signal probes (pointing device) at each reference point, and inference parameters must be chosen according to the specific characteristics of the region. In fact, the number of reference points determines the reliability of the inference. LIS allows the administrator to define logical regions of arbitrary size and rectangular shape and a hierarchical description of regions and their nested sub-regions. This functionality is implemented in the Symbolic Region Manager (SRM), which provides an interface to define (create, modify and delete) and request information about hierarchies of symbolic regions, which are names assigned to well defined physical regions (i.e. rooms, halls, buildings and surroundings) that may be of interest to location-aware applications. All symbolic regions should be based in the set of atomic regions defined by LIS Administrator. Finally, the Server API automatically registers in the Discovery Service (DS), a server in charge of storing information, such as name, properties, addresses for any application (i.e. its servers and proxies) or any service registered with the MoCA middleware, in order to have its addresses available to be found by prospective clients.

B. Software Components and Dependencies

MoCA consists of a set of APIs that comprises communication infra-structure, core services and optional services. Fig. 3 presents the dependencies between the API modules.

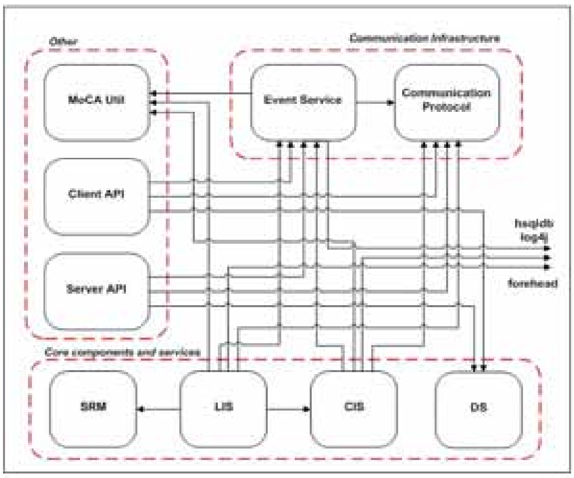

Fig. 3: MoCA API's dependencies graph

C. Registering and executing a collaborative application -Algorithm

Fig. 4 shows the typical sequence of interactions among MoCA's elements, illustrating the roles these elements play during registration and execution of a collaborative application [6,7].

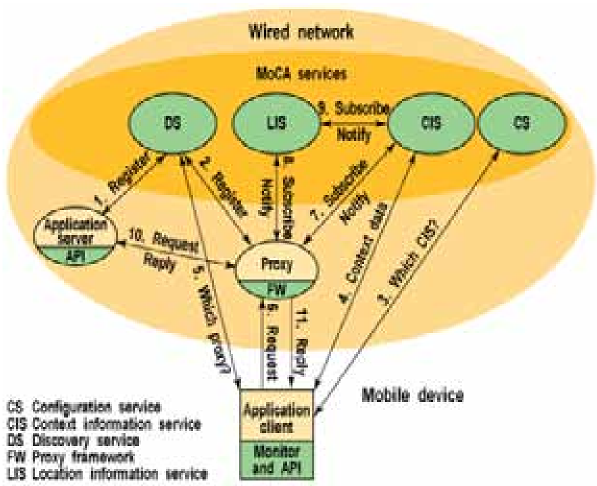

Fig. 4 : Roles during registration and execution of collaborative application

Step 1: Initially, the application server registers itself at the DS.
Step 2: Informing the name and the properties of the collaborative service that it implements. Each proxy of the application also performs a similar registration at the DS.
Step 3: This way, the application clients can query the DS to discover how to access a given collaborative service in their current network usually through the closest proxy. The monitor executing on each mobile device polls the state of the local resources and the RF signals and sends this context information to the CIS.
Step 4 : Thereafter, the monitor periodically sends the device's context data to the CIS.
Step 5: After discovering a proxy that implements the desired collaborative service through the DS.
Step 6: The client can start sending requests to the application server. Each request gets routed through the corresponding proxy.
Step 7: Processes the client's request, applying the application's specific adaptations, and forwards it to the application server. For example, the proxy might subscribe at the CIS with an interest expression.
Step 8: Registering its interest in notifications about context changes of a particular client (device). Now, whenever the CIS receives a device's context information (from the corresponding monitor), it checks whether this new context evaluates any stored interest expression to true. If so, the CIS generates a notification and sends it to all proxies that have registered interest in this change of the device's state. Applications that require location information register their interest with the LIS.
Step 9 : In turn subscribes to the CIS.
Step 10 : To receive periodic updates of the device's RF signals. The LIS uses these signals to infer the device's location and send the corresponding notification to the application proxy. When the application server receives the client's request, the request is processed and a reply is sent back to some or all proxies.
Step 11: Then adapt or process the reply according to the new state of the corresponding mobile device on its wireless connection.
As depicted above context specific adaptation depends on the collaborative application's specific requirements. For example, if the proxy is informed that the quality of a mobile device's wireless connectivity has fallen below a certain threshold, it could temporarily store the server's reply data in a local buffer for an optimized bulk transfer, remove part of the data and apply compression to the data only. Moreover, the proxy could use other context information, such as the device's location, to

determine when and how data should be delivered to the client. The architecture also implements mobility transparency for the applications. When a mobile device moves to another network, the monitor detects this and the CIS notifies the proxy. The proxy performs the handover at the application level by determining the most appropriate proxy for the device in the new network, and if the proxy is available, the collaboration session state is transferred to this new proxy.

V. PAN-Personal Area Network

Personal Area Networks (PANs) are low cost, low range networks that allow users to create spontaneous ad hoc networks that do not depend on any central node, see fig. 5. These ad hoc network technologies enable devices to detect and connect to other devices that are in sufficient proximity and form mobile peer-to-peer (P2P) networks. Ad hoc network technologies are ideal for transmitting information and synchronizing data, making them a viable solution for sending messages between users in a mobile network. Utilizing PAN technology for mobile phones enables for a broad range of collaborative applications supporting collocated work and spontaneous interaction. Development of applications requires a lot of effort not only from many stakeholders at implementation time, but also when it comes to capturing domain concepts, understanding underlying technology, and creating the necessary infrastructure for the application. Since the market for development of mobile applications is quite young and the technology itself is quite immature, there are not many regular building blocks available that can be used to build the actual applications. Frequently this leads to developers reinventing the wheel by implementing almost similar infrastructures.

A. Mobile Ad Hoc Networks (MANNET)

MANETs are spontaneous, self-configuring, wireless networks with no fixed infrastructure [7]. As devices supporting ad hoc networking are moved around, they are able to detect and connect to other devices that are within a given proximity. When the devices are out of range from each other, the connections are broken. In this way, the devices form spontaneous networks with the possibility of exchanging information. Today's cellular systems, like the Global System for Mobile communications (GSM) and Universal Mobile Telecommunication System (UMTS) networks, rely heavily on the infrastructure. Base stations provide coverage, and services are integrated into the system. This architecture provides good and predictable services, which suits well for cellular telephony. Ad hoc networks have a number of advantages compared to traditional wireless cellular networks as listed below.

1. No infrastructure required

Ad hoc wireless networks do not rely on wired base stations and for that reason can be deployed in places without existing infrastructure [7]. They can be created spontaneously and on as needed basis, because they require little configuration to setup.

2. Self-organization

In a wired network the connection topology of nodes is determined by the physical cabling and therefore is fixed. This restriction is not present in an ad hoc network. As soon as two nodes are within proximity of each other, a communication link between them is automatically formed. As a consequence, the network topology of an ad hoc network reflects the relative distance of its nodes and is continuously reconfigured as nodes come within the reach of each other. Depending on the coverage range, ad hoc networks are divided into four main classes as depicted in fig. 5. As the coverage range increases so does the power consumption, requiring more and more powerful devices. A Body Area Network (BAN) is a network of components distributed on a human body. This could be wearable devices like mobile phones, MP3 players, headsets and microphones etc, that are connected with wireless technology. The range of BANs corresponds to the human body range, about 1-2 meters. A Personal Area Network (PAN) connects mobile devices carried by users to other mobile and stationary devices. The communicating range of a PAN is normally up to 10 meters. Available PAN technology is further described and evaluated in Wireless Local Area Networks (WLAN) and has a range of a building or a part of building, about 100-500 meters. Wireless LANs can be implemented in two different ways. One way is to use some kind of cell-based infrastructure with a centralized controller for each cell. Another way is to use ad hoc networks for devices to communicate directly.

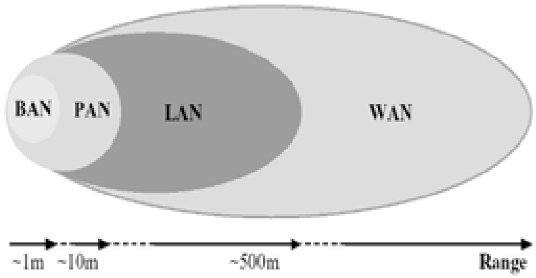

Fig.5 :T axonomy of ad-hoc networks

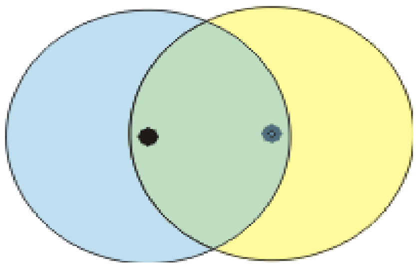

Fig.6 : Single-hop ad-hoc network

A Wide Area Network (WAN) covers a much larger area than the other classes. A WAN may cover areas like a campus or a part of a city. MANETs [8] can also be classified in the way the nodes form and communicate. We distinguish between single hop and multi hop networks as shown in fig.6 and 7. In single hop networks nodes can communicate directly and are in reach of each other. In multi hop networks some nodes are out of reach from each other and cannot communicate directly. Therefore, the traffic between these nodes has to be forwarded by other intermediate nodes. The fig.7 shows a multi hop network and the communication path between the far nodes is given by the black lines.

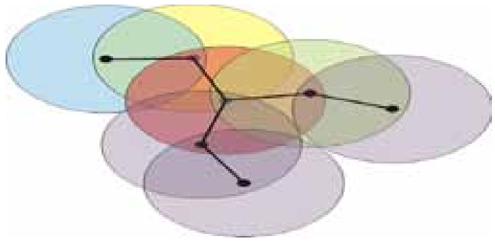

Fig.7 : Multi-hop network

B. Frameworks

A lightweight framework for ad hoc applications

A lightweight ad hoc application framework has been developed by Garbinato and Rupp at Universite de Lausanne, Switzerland.

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Garbinato and Rupp defines an ad hoc network in terms of distance among nodes, willingness to collaborate and the dynamic features of P2P networks.They define an ad- hoc application independent of a specific underlying ad hoc network technology and focus on the applications aspects. A lightweight application framework is well documented for references. This framework is independent of any underlying ad hoc network technology and is based upon existing standards, like JXTA.

VI. Mobile Computer Supported Cooperative Work

Mobile CSCW can be defined as "Working together at various sites with the use of mobile IT". This means that using mobile phones or other portable devices as a platform for deploying CSCW applications places us in the domain of mobile CSCW[8]. Today mobile phones have several advantages when it comes to the area of CSCW. Mobile phones are highly personal and most users carry their mobile phones with them at all times. This has some major implications on the use of mobile phones for CSC purposes. The features of concern are:-

A. Identification

Since the mobile phones are personal, they can be used to identify a user.

B. Personalization

A user can store his or her profile on the mobile phone, enabling the mobile phone to function according to the user's specific needs when interacting with other users.

C. Availability

Mobile phones can almost be considered to be always on, always present. Due to this, some one using their mobile phone for CSCW purposes will achieve a high degree of availability to other users.

VII. obile Collaboration will make Unified Communication a success

One area where there has been great advancement is in the collaboration space called "Unified Communications" (UC). This means that the technologies for audio (PBX), video (both room-based and web cams) and Web/data conferencing, IM (instant messaging, chat), presence and location are all integrated into the communication infrastructure of the enterprise [9]. Unified Communications can provide genuine benefits for the everyday office works, but these benefits can be multiplied significantly when the solution is extended to the mobile worker. An effective 'Mobile' UC solution can eliminate many of the reachability, productivity and cost issues associated with business mobility. An effective Mobile UC solution would be designed to enable the mobile worker to communicate as easily and effectively on the road, as they can be within their office. The Final Piece of the UC Puzzle examines applications in the mobile collaboration market, including a comparative analysis of solutions and the most promising applications found in mobile collaboration. It also examines target market sizes and vertical market strengths, as well as how vendors recommend achieving operational savings. Further, it examines trends in the industry and a look at the supply chain. Vendors believe that the integration of mobile into unified communications will finally bring widespread success to that industry Some hot applications for mobile collaboration include mobile presence, mobile IM, and the ability to turn mobile handsets into virtual PBXs and most target markets for mobile collaboration vendors remain vague, as vendors try to address every market with their solutions. Such as Healthcare and education will be the strongest verticals for mobile collaboration over the next year. Open source solutions present both opportunities and challenges, as vendors seek to make their solutions stand out while focusing on the bottom line.

VIII. Next Generation of Mobile UC-Benefits of Mobile Collaboration

According to multiple analysts and research companies, the next several years should see a surge in Mobile UC deployments [10]. Many of the technological prerequisites for its broad adoption are now in place. New 3G and 4G mobile broadband networks provide increased bandwidth and broader coverage for network operators around the globe. In addition, 802.11-based WLANs are faster, boast a longer range, and because of new standards in wireless security, they can be as secure as legacy wired networks. WLAN and Wi-Fi have become almost universal in the enterprise, at home, and with the growth of public hotspots and many places. Pervasive wireless provides the 'meta' network required for Mobile UC.

There are four major benefits from mobile collaboration:

1. Saving time or money (tangible).
2. Increasing quality.
3. Innovating and/or providing decision support (tangible, but less than quality)
4. Easing access to and interactions with subject-matter experts (intangible)

IX. Conclusion

Our future living environments are likely to be based upon information resources provided by the connections of various communication networks for users. New devices like personal digital assistants, mobile phones and handheld sets are advancing information processing and accessing capabilities with mobility. Moreover, traditional home appliances and gadgets such as digital cameras, washing machines, cooking ovens and refrigerators with computing powers attached would extend the field to a fully pervasive computing environment. In the near future, mobile computing environments are expected to be based on recent advancements in computing and mobile technology. In mature markets 60-80% of smart phones will be shipped in the year 2012. In emerging markets 15% to 30% smart phones will be shipped. The intermediate markets falls between mature and emerging market shipment levels. The smart phones would use platforms like Symbian, Android, iPhone very extensively . By 2013 GPS and WiFi will become increasingly popular in smart phones, OLED screens allow thinner devices and better battery life, E-compass complements GPS in high-end devices. This paper has addressed the issue of how mobile collaboration is a inevitable technological avenue for Unified Communications and has discussed its frame work extensively.

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