Using Mobile and Wireless Computing to Facilitate Virtual Collaboration During a Pandemic

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Abstract

People used physical meetings and gatherings to collaborate with others in the past. However, this physical collaboration no longer works during a pandemic because people are required to keep social distance, stay away from the crowd, and even work or study at home. A new way of collaboration using mobile and wireless computing, like Zoom, Slack, and Teams, has started to flourish. Mobile and wireless computing does facilitate virtual collaboration without doubt, but it also brings new concerns like security and privacy issues, which do not occur often during physical meetings or gatherings. A secure and privacy-preserved remote environment is essential for the confidential information shared over the virtual platforms because the cloud-based tools have the threat of unauthorized access and data jeopardizing. This article discusses various issues related to using mobile and wireless computing to facilitate virtual collaboration during a pandemic, and how and what technologies are used to preserve user privacy while participating virtual collaboration and make mobile and wireless computing more secure.

Keywords: *Mobile and Wireless Computing, Virtual Collaboration, Security, Privacy Preservation and Inter-Disciplinary Communication.*

1. Introduction

Collaboration is essential for individuals and organizations. The traditional ways of collaboration no longer work during a pandemic. This article discusses how mobile and wireless computing can facilitate virtual collaboration. However, with the development of new technology, new security concerns arise. It is challenging to address all security issues at once. Malicious attackers tend to find and exploit these security loopholes. Organizations and employees should be aware of these malicious activities and necessary measures to secure their environment. Moreover, there is an extended risk during virtual collaboration as the employees use their personal devices over a private wireless connection. While organizations use a rigid security measures on their devices and wireless networks, it is not feasible to secure employee's personal communication devices. The issues related to security of mobile and wireless computing for virtual collaboration and how to preserve user privacy will be addressed too.

Inter-disciplinary communication: Due to the limited availability of evidence on the virus, people must follow social distancing. Most of the countries go under complete lockdown to minimize the spread of deadly disease. The traditional ways of collaboration no longer work. Fortunately, mobile and wireless computing becomes a life savior to collaboration, and individuals and organizations start shifting to virtual collaboration. They use all kinds of mobile and wireless tools like Zoom, Microsoft Teams, Google Meet, Cisco WebEx, and Skype to facilitate virtual collaboration. These tools provide a unified learning system where participants can join-in by using a shared link for real-time interactions with other participants that taking place over wireless communication devices. They include the features such as audio and video support, virtual background, chat boxes, polls, data sharing, etc. Platforms like these help individuals and organizations to manage communications and improve productivity.

Rigor: Mobile and wireless computing does facilitate virtual collaboration, but it also poses concerns such as security, privacy, and misinformation. A secure and privacy-preserved remote environment is essential for the confidential information shared over the virtual platforms because the cloud-based tools have the threat of unauthorized access and data jeopardizing. In the era of smartphones, functions like voice, camera, GPS (Global Positioning System), call log records, contact details are extensively used. Moreover, mobile devices host crucial financial information such as credit card and bank account details. The development in mobile communication urges the responsibility to protect the devices and the data within. There are several threats to mobile and wireless computing. For instance, theft of sensitive data, wireless intruders capturing email addresses, email content and attached data, data leakage due to portability, malformed messages causing devices to crash, and substantially more. These threats and countermeasures to the mobile and wireless communication will be considered and discussed.

This article studies the technologies used for virtual collaboration and is organized as follows. Section 2 discusses various kinds of physical collaboration and how to convert the physical collaboration into virtual collaboration. The technologies used to achieve virtual collaboration are then introduced in Section 3. Security and privacy preservation are critical for virtual collaboration, and they will be examined in Section 4. The final section gives a summary of this article.

2. Physical and Virtual Collaboration

Virtual collaboration is an approach to work on similar objectives, although geographically separated via wireless tools as mediators. It is a method that uses wireless communication despite working from different locations at

different times. Especially during a pandemic, people realized the importance of using virtual collaboration tools to keep up with the work. Virtual collaboration tools like Zoom and Google Meet allow people to connect instantaneously and effortlessly. On the other hand, physical collaboration is working together at the same time, place, and environment while being physically present together. Physical collaboration allows people to socialize and learn from each other in-person. There are several types of physical collaboration, like workshops, seminars, one-to-one meetings, idea sharing conferences, and potentially more. Some of the different kinds of physical collaboration are discussed next.

2.1. Types of Physical Collaboration

Before virtual collaboration is discussed, we need to know what kinds of collaboration exist. This section introduces various types of physical collaboration including seminars, manufacturing, idea sharing and discussion, and assignments.

2.1.1. Seminars: Professional and personal development workshops or seminars are prevalent in business groups. Professionals from various fields attend seminars to exchange their thoughts, build future connections, and learn from experienced workers. In the case of students, seminars help to meet potential recruiters, learn about upcoming technologies, and develop skillsets. Physical collaboration allows participants to socialize with a wide variety of experts from different sectors. Figure 1 shows the benefits of physical collaboration. Amidst the pandemic, seminars, conferences, and workshops were either canceled or moved to virtual collaboration.

Figure 1: Benefits of physical collaboration.

2.1.2. Manufacturing: Manufacturing is a process of converting raw material to semi-finished or finished goods using various tools, machines, and techniques. There are different kinds of manufacturing industries such as automotive, aerospace, clothing, pharmaceuticals, food and beverage, personal care to satisfy human needs. There are hundreds of employees who work in these industries. During a pandemic, it is challenging to follow social guidelines to create a safe working environment. Manufacturing

companies can accommodate their employees to remote work by modifying their hardware. However, in certain circumstances they need a large number of workers to accommodate the on-site production processes.

2.1.3. Idea Sharing and Discussion: Idea sharing and discussion is a method to express one's thoughts to another. It can be for the development of a project, assignment, or an invention. Idea sharing can be done both in-person and virtually. Discussion can happen one-to-one, one-to-many or many-to-many. Seminars, conferences, workshops are some mediums where people can discuss their ideas with one another as shown in Figure 2.

Figure 2: Methods of idea sharing and discussion.

2.1.4. Assignments: Assignments are usually homework, or an exercise given by the professor to the students. The primary purpose of an assignment is to aware the students with responsibility, originality, and authenticity. There are two types of classes wither in-person or online. Students who prefer in-person classes, can explore and work with other students and clear their doubts from professor anytime in the class. In contrast, online students communicate via wireless technologies to clear their doubts and work on their assignments.

2.2. Converting Physical Collaboration to Virtual Collaboration

During an epidemic, people must follow social distancing to minimize the spread. During these times, virtual collaboration becomes a necessity where people are connected through technology but are disconnected physically. Before 2020 pandemic, virtual collaboration was not as advanced and explored. Mostly, people used to meet in-person for discussions and idea sharing. Moving to virtual collaboration is not easy for workers who have never used this medium, especially when they have to work from home as shown in Figure 3. Nowadays, there are various virtual collaboration tools like Zoom, Google Meet, Skype, Facetime with many advance features. These tools help companies to keep up with the work even during these unprecedented times. There are several benefits and limitations of wireless communication as discussed follows.

Figure 3: Conversion of physical-virtual collaboration.

2.2.1. Benefit: Companies are becoming more receptive to new ways of collaborating. Advantages of virtual meetings such as little to no travel time and cost is hard to ignore. This in turn increases productive, saves cost, and promotes eco-friendliness. With the help of virtual collaboration tools, remote work practices have increased by 44% in the last five years according to FlexJobs.com. Educational institutes and organizations also benefit in several ways by implementing a virtual collaboration strategy. Some of these advantages are listed as follows:

- Cost-saving by reducing daily travel and accommodation costs
- Productivity by saving time spent in travelling, getting ready for conferences and meetings, etc. Now, the employees have more time to work on their projects.
- Sustainability by reducing CO_2 emissions and leaving a positive impact on the environment
- Satisfaction as employees have more time to spend with their families, care for their well-being which in turn increases satisfaction and boosts competence

2.2.2. Limitations: Wireless communication is growing rapidly, especially during a pandemic and becoming a permanent feature of organizations. Companies are drawn by its cost-effective method allowing employees to work from anywhere via any internet-enabled device. However, online collaboration has its drawbacks as follows:

- *Security*: Wireless communication typically uses a cloud-based structure which makes it unreliable and prone to viruses.
- *Audience*: Online collaboration provides a wide range of audience to its users which leads to diffusion of focus. With a great choice of people to collaborate, people get confused about why they need to engage with them in the first place.
- *Management*: It is difficult for managers or supervisors to track the progress of each employee and the project remotely. Also, it can be challenging clear about milestone to employees in case employees have a lot of question about the project.

- *Cost*: For virtual collaboration, it is crucial to choose an online tool for a company to avoid any future confusions. The online collaboration tools can be a bit expensive and may provide limited access to users. For instance, Zoom offers a $200 plan annually per license for small and medium businesses.

According to the article of the 2020 state of remote work [1], Figure 4 shows the struggles of working remotely.
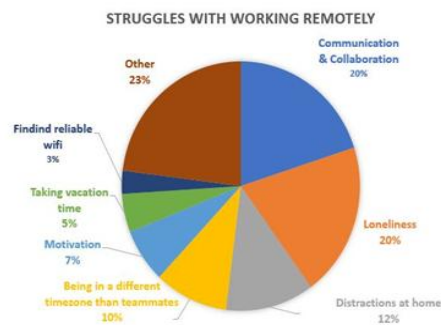

Figure 4: Drawbacks of working remotely.

3. Mobile and Wireless Computing for Virtual Collaboration

Virtual collaboration is the process of people or organizations working together to complete a task, but not physically. It is mainly achieved by using mobile and wireless computing (Buffer & AngelList, n.d.), which will be discussed in this section.

3.1. Mobile and Wireless Systems

Wireless technology can help organizations with communication, conferencing, storage, and classification. Employees can talk to each other with virtual messaging tools and organize their projects more centrally. The central hub for messages and storage allows companies to keep track of everything happening in their workplace. The wireless communications have their advantages and disadvantages which are discussed briefly in this section.

3.1.1. Virtual Meeting Means: During a pandemic, companies shift to the virtual meeting tools like Zoom, WebEx, Google Meet, Skype and many more. These tools offer organizations a reliable platform for audio and video conferencing. Virtual conferencing tools allow them to strengthen the links between their distant employees. Also, when social distancing rules are imposed, companies have to conduct job interviews, project progress meetings, and personal meetings virtually. Similarly, educational institutes use virtual collaboration tools to teach online classes, conduct exams,

schedule job interviews, etc. The mobile and wireless communication are truly helpful to stay informed regardless of time zone and location, but it makes the companies vulnerable to cyber-attacks. It also requires quality internet connection speed and equipment. Figure 5 shows a successful online class on Zoom conferencing mobile application.

Figure 5: Example of a Zoom screen in an educational institute.

3.1.2. Document Sharing/Storage Means: For an enterprise, a reliable document/file management is essential to keep their client's information protected. Especially during a pandemic, it is necessary for employees to collaborate for a successful resolution of issues. In the past, basic paper file systems were effective but storing the files in a cabinet does not work in the wireless communication world. Document sharing tools like Amazon Web Services, Dropbox, Google Drive, OneDrive allow their users to handle permissions by monitoring who can access the files, and when. Table 1 shows the comparison among cloud-based document storage/sharing tools. These tools also enhance productivity as it is easier to share the files via emails rather than paper files. It is easier to collaborate via these platforms as they provide real-time communication, sharing and feedback for its users.

Table 1. Comparison among cloud-based document storage/sharing tools.

Cloud Service Providers	Best for	Features	Free Storage	Cost (/month)
Dropbox	Freelancers & medium business	Quick file share & sync	2GB	$12.5
OneDrive	Freelancers, medium and large business	High speed, collaboration, and connectivity	5GB	$1.99 & 50 GB
Google Drive	Freelancers, medium and large business	Storing and syncing files	15GB	$5-$10
Amazon Web Services	Freelancers, small, medium, and large business	Copying at block level GUI	5GB	$15 & 3TB

3.1.3. Project Management Means: Project management tools such as Asana, Microsoft Project, Smartsheet, Primavera, Basecamp, etc. help to manage and plan the projects amongst a team through task assignments and

scheduling. These tools allow managers to monitor the progress of a project daily while sitting at home, and similarly, group members can also check other members' progress as shown in Figure 6. Project management tools provide following essential features for successful virtual collaboration:

- Schedule and time management: Project management tools record each employee work time and then schedule their working hours accordingly.
- Communication and collaboration: They allow users to post comments while keeping all the historical records.
- Project budget: These tools keep a real-time check on the project's allotted budget along with project time.
- Easy to use: Mostly, project management tools like Microsoft Project and Smartsheet are user-friendly, which makes them easy to adapt to an organization.
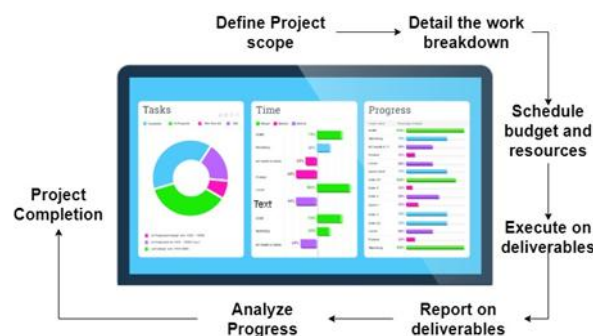

Figure 6: A typical life cycle of virtual project management tools.

3.1.4. Unmanned Aerial Vehicle/Drone Technology: UAV is an unmanned aircraft which can be guided autonomously or by remote control. It carries sensors, target designators, an electronic transmitter which are designed to achieve the desired targets. The drone became a crucial virtual tool in COVID-19 pandemic by helping supply chains and socially distanced delivery services. Companies like Walmart, Amazon are planning to start a new delivery system using drones which will allow people to have their groceries or accessories delivered in their backyards without physical contact (Agha, Pujolle, & Ali-Yahiya, 2016). Similarly, UAV is helpful in industries like agriculture, construction, mining, entertainment, etc., where drones can perform inspections and surveys quickly, safely, and economically than helicopters or people. Drones can quickly gather large amounts of visual data and access places that are hard to reach usually. Drones are especially useful for emergency response services, particularly during a lockdown to deliver medical supplies, accessories to stranded victims. In a way, UAV technology is moving from hyped-up technology to a virtual tool that can perform daily tasks amidst a pandemic. Figure 7 shows the applications of a drone technology.

3.1.5. Slack: Online courses are getting famous from the last decade, which allows students to study from anywhere in the world. Similarly, it applies to

employees who work from home. Slack provides a single place for messaging, storing files, and tools, which means Slack is an instant messaging tool with various add-ins options for other workplace tools . Slack (Marks, 2020) allows its users to create multiple channels, for instance, a company can create channels for each of its clients and include the employees separately associated with a client or a project. These channels can be public, private, or shared. It allows the organization to manage their projects, clients, and employees at the same time. Also, data on Slack can be downloaded straight to the user's desktop. However, Slack keeps the conversations amongst the channels for only 14 days, and due to its minimum file storage, it slowly keeps on deleting files over time. Slack is a useful tool for team communication and is perfect for quick response conversation. There are various other collaboration tools available in the market nowadays to give Slack a competition like G Suite, Miro, Blizz, and potentially more. Table 2 compares the various collaboration tools other than Slack available in the market.

Figure 7: Applications of drone during or after a pandemic.

Table 2. Basic comparison amongst virtual collaboration tools.

Tool	Price (/user/month)	Benefits	Drawbacks
Slack	$6.67	Multiple channels & great security	Minimum file storage and new notifications all day
Blizz	$6	Easy and quick setup; supporting high resolution videos	Requiring high-speed internet connection for high resolution videos
G Suite	$6	Allowing users to edit the documents offline and sync them later	Poor formatting options and file sharing
Miro	$8	Whiteboard feature for project planning and quick support team	Complex interface and poor video quality
Samepage	$3.35	Collaboration functions such as instant chat, document editing	Poor navigation controls in the Android mobile application

3.2. Technologies Behind

The workforce and workplaces are changing drastically from the last five years. Organizations are hiring remote, part-time, and freelance employees. Mostly, during a pandemic, when even full-time employees work from home, wireless communication plays an important role. It is essential to improve virtual collaboration tools and techniques with time. Users want a better experience, quality, and quick response times from their wireless technologies. There are few technologies that help to improve the mobile and wireless computing tools which are discussed as follows in detail.

3.2.1. Application Programming Interface Integration: The API integration is a connection amongst two or more applications using their application programming interfaces that enables interaction between data, applications, and devices (Mehlhase, Heinrichs, & Gary, 2019). APIs process the requests and create seamless communication between applications. It allows its users to integrate tools from the cloud and existing enterprise applications. For instance, API integration enables companies to incorporate Dropbox, Google Drive, Asana with Slack. It allows companies to run their projects virtually, effortlessly, and effectively. Figure 8 shows how integration tools help an organization to keep all their devices in one place. Integration platforms and APIs work together to help businesses to integrate and manage their organization with higher efficiency. Also, it saves companies time, money and transition process for employees working from home.
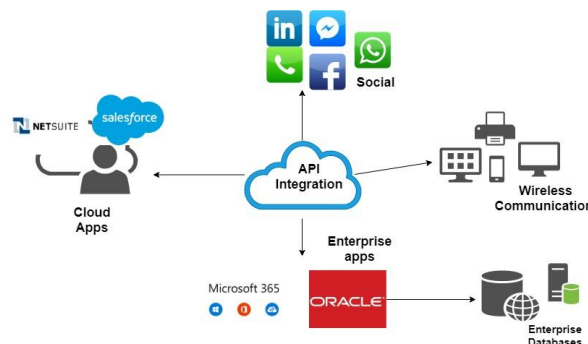

Figure 8: API integration in an organization.

3.2.2. Augmented and Virtual Reality: AR and VR are very popular in the video gaming industry. However, they have been incredibly explored for the enterprises and businesses (Newman, n.d.). The virtual reality is being used by most of the video conferencing virtual apps like Zoom, WebEx, and Google Meet, which allow their users to change their background to enhance the presentation environment. There are some virtual tools for

presentation preparation like PitchVantage, which create a boardroom and provides feedback using robot's body language that allows users to feel connected to the room. On the other hand, augmented reality allows interactive experience with real-world objects enhanced with sound, video and graphics modules. For instance, medical students can view the organs during a surgery without having an actual patient. Some instances of AR and VR in an organization using virtual tools are given in Figure 9.

Figure 9: Instances of AR and VR in an organization using virtual tools.

3.3. Pros and Cons

This section will discuss the benefits and drawbacks of virtual collaboration. Many organizations are able to benefit from virtual collaboration tools, whereas some organizations are finding the current technology insufficient to meet their requirements (Muñoz-Saavedra, Miró-Amarante, & Dominguez-Morales, 2020).

3.3.1. Benefits: Virtual collaboration solves many communication problems during a pandemic. It offers the following benefits:

- Virtual Collaboration offer lower overhead cost, higher scalability, high employee satisfaction and higher efficiency.
- Virtually, companies do not have to worry about leasing office space, furniture, utility cost, electricity, Wi-Fi, and other related expenses.
- Work from home employees desires flexible hours which is possible with virtual collaboration. It provides an opportunity for companies to hire talented employees from all around the world.
- The wireless communication allows the formation of multi-cultural and multi-major teams based on their skill set and requirements.
- There is no requirement for office space and location as the employees work from home. An organization can hire as many employees as possible regardless of geographical location.

3.3.2. Drawbacks: Virtual collaboration is critical for inter-disciplinary communications without doubt, but it also suffers the following drawbacks:

- The foremost disadvantage of virtual collaboration is lack of companionship, cohesiveness, and a risk to organization's reputation and security.
- It is a significant risk for companies to have confidential information on remote platforms.
- The accidental loss or release of data can cause serious repercussions, for financial services or healthcare industry.
- With irregular working hours, it can be difficult for a manager to coordinate with the employees, which can create a burden in managing life and work requirements.
- An extended risk during virtual collaboration is that employees use their devices over a private wireless connection. While organizations use stringent security measures on their devices and wireless networks, it is not feasible to secure each employee's private communication devices.

4. Security and Privacy of Virtual Collaboration

In the era of digital transformation, with AI, blockchain and an array of IoT devices, technologies are capable of influencing our professional and personal lives (Mehta & Shah, 2019). However, enterprises need to mitigate the risks in order to improve their business productivity and outcomes. During a pandemic, it becomes essential for companies to move to online collaboration tools such as Slack, Zoom, Microsoft Teams, and Google. These tools are expensive and are not very secure in terms of data security and confidential information. The sudden transition to online collaboration tools lacks the right experience and knowledge. The online collaboration tools can deliver considerable benefits to the companies, but they also need to address the challenges of virtual tools without exposing themselves to undue risk.

4.1. Technologies Used

Every day, with the development of new technology, new security concerns arise (Leob, 2018). It is challenging to address all security issues at once. Malicious attackers tend to find and exploit these security loopholes. While there is an issue of the right experience and knowledge to use these tools effectively, Zoom recently admitted that it had been sending the device information data to Facebook whenever an account has been made using "Login with Facebook" feature.

4.2. The Problems

There are issues such as insider threats which include data exfiltration from malicious insiders. There are also agreement and data risks which can be

posed by virtualizing the entire workplace like inappropriate messaging, bullying, harassment and sharing of personally identified information. The security teams which are still running traditional Data Loss Prevention (DLP) tools will not be able to control today's cloud environments. Also, security teams cannot block users from the cloud while working with a fully remote workforce. However, legacy security and data loss prevention tools need to improve their technology to secure this new virtual working environment (Goodchild, n.d.).

4.3. Multi-Factor Authentication

Mobile and wireless communication causes a sharp rise in phishing attacks in an attempt to capitalize especially during a pandemic. Companies need to take extra precautionary steps to reduce the impact of phishing attacks and protect their organizations and employees credential information. Rather than just relying on strong passwords, companies should use multi-factor authentication to avoid unauthorized access. It will ensure that there are no forged logins which will help them to keep their information secure and safe. There are various mobile applications like Duo Mobile, which sends a push notification to confirm an activity on an account. Similarly, Google, Microsoft, and Facebook provide multi-factor authentication feature in their applications to keep them secure from malicious attacks. Figure 10 depicts the basic structure of two-factor authentication.

Figure 10: Multi-factor authentication.

4.4. Classification and Handling

There are multiple pieces to the successful telecommuting and remote collaboration. The networks, applications and end user devices must work together to deliver the right user experience in a secure and private environment. To keep an organization's remote workflow running smoothly during a pandemic, companies should follow necessary classification and handling technique. Companies can classify information based on sensitivity across their organization like public, confidential, or internal data. They can define rules to handle different type of information across their virtual collaboration tools such as designating specific access control, which in turn can train their devices according to the company's requirements. Enterprises need to leverage built-in features of their virtual

tools like auto-detection, forwarding restrictions for electronic mail in order to handle the various information classes.

4.5. Virtual Tools Built-in Features Utilization

During a pandemic, virtual work becomes an essential part of our lives. To ensure business continuity, organization switch to virtual collaboration tools like Slack, Zoom, Microsoft Teams, etc. But the shift to virtual work has exposed enterprises to several security and privacy challenges. It is already hard enough for managers or organizations to handle everything remotely. But without proper controls and checks on virtual tools, it can expose an organization to serious risks (Rodriguez, n.d.). The right utilization of built-in security features of these virtual tools can resolve lots of small threats and issues. Companies pay a lot of money for virtual collaboration tools. They need to utilize them properly in favor of their organization's requirements. The right knowledge and right tools are essential for the security and privacy of privileged information. Table 3 highlights some in-built security features of popular collaboration tools.

Table 3. Security features of different virtual collaboration tools.

Virtual Collaboration Tool	Security Features
Microsoft Teams	• Two-factor authentication • Single sign-on through active directory • Advanced threat protection to block malicious content • Enforces conditional access policies for teams
Slack	• Mobility management to ensure authorized users • Data is protected using Slack Enterprise Key Management integrated with DLP providers. • Hold security attestations such as ISO/IEC 27001 and ISO/IEC 27018.
Google Drive	• Two-factor authentication • Account recovery options • Control who can access to the data • Encrypting uploaded data to secure it from malicious attacks • Securing their accounts using Titan keys
Zoom	• In-meeting security options like lock meeting, enable waiting room, remove participant, and report a user • New updates or version from time to time • End to end encryption • Security-first approach adoption recently
Asana	• Using Amazon's relational database services to manage user data • SAS 70 audited data centers • Flexible to move the data to a different data center in case of current database failure. • Access to users who can authenticate via Google accounts or set up SAML

5. Summary

The COVID-19 pandemic causes a world catastrophe and creates serious problems, but at the same time many application and research opportunities are created because of it. Due to the COVID-19, people require to keep social distances and avoid the gatherings as possible as they could, but many works like team projects, employee training, product manufacturing require people's collaboration and participation. The traditional physical collaboration no longer works during a pandemic. Virtual collaboration starts to replace or complement the physical collaboration. However, virtual collaboration is easier said than done because many problems like security and privacy need to be solved before it could be widely accepted. This article discusses various issues related to virtual collaboration including types of collaboration, mobile and wireless computing for virtual collaboration, and the technologies to make the virtual collaboration more secure and to preserve the privacy of participators. This article will help readers enhance their knowledge of virtual collaboration and perform virtual collaboration extensively and securely. Though virtual collaboration security and privacy have been improved significantly recently, they are still the greatest concerns for its users. If the concerns are not completely relieved, virtual collaboration will not be lifted to a higher level. Better security and privacy of virtual collaboration will be the future research direction of the authors.

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