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Challenges in online collaboration to augment Industry 4.0

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Abstract: The upsurge of the COVID-19 pandemic has made organisations transit their employees to work from home (WFH) using online collaborations. WFH culture offers advantages like increased productivity, reduced business travel, compact office politics, more focused time, etc., in line with the goals of Industry 4.0. However, there may be risks due to system flaws generated by online collaboration, which may allow an attacker to access the system and lead to breaches of security, privacy and trust during online collaboration. The paper presents a framework for online collaboration using three important issues of security, privacy and trust. It presents different incidents related to the importance of each of the issues and factors affecting them during online collaboration. The framework will help in the design of online collaboration policies for Industry 4.0 environment.

Keywords: COVID-19; WFH; work from home; security; privacy; trust; Industry 4.0.

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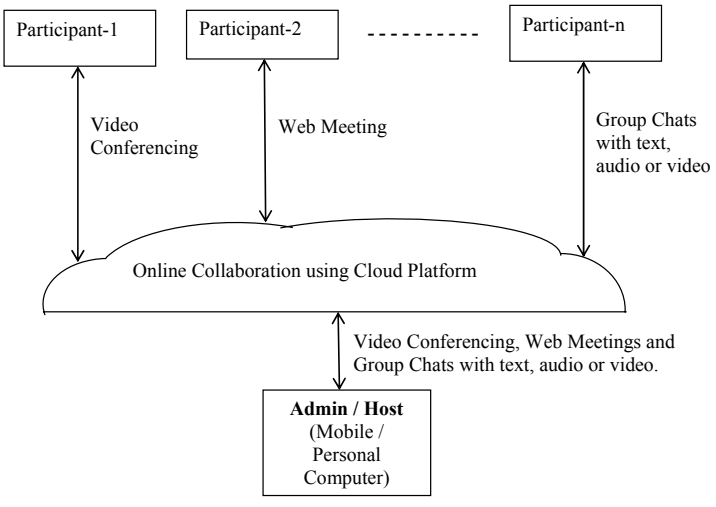
1 Introduction

Online collaboration is a process of connecting users in a team, making use of a digital platform and internet (Strauß and Rummel, 2021). The platform used allows team members to chat through text, audio and video means of communication. It is a pinnacle for team work, which allows organisations to improve communication and strengthen project efficiency (Ma et al., 2021). It also provides features like file sharing, online data storage for consistency among team members and maximise creative efforts. Online collaboration can be established using any of the cloud platforms available like Zoom, Microsoft Teams, Google Meet, Cisco Webex, Bluejeans, GoToMeeting etc. (Russell et al., 2021). The meeting for such collaboration is initiated by the host or the admin which can work through mobile phone, tablet, personal computer, laptop etc. Also, there is no restriction for the use of operating system like it can be Windows, Linux, Macintosh, Android or IoS etc. Online collaboration can be established using any of the means of communication like video conferencing, web meetings or group chats with text, audio or video (Kumar and Bhardwaj, 2018). Mostly for free version number of participants is only 100 and the time limit is 45–60 min only. But for licensed versions, number of participants who can attend and the time limit for the online collaboration can be dynamically set by the platform provider (Johns and Mills, 2021). An online collaboration using cloud platform which combines video conferencing, web meetings and group chat with host, administrator and participants is shown in Figure 1.

The upsurge of COVID-19 pandemic has contended governments throughout world to implement lockdowns for preventing burden on their health infrastructures (Kumar and Malhotra, 2021). Online collaboration tools are helping people during COVID-19 pandemic through daily life by providing platform for personal chats with friends, family members, business meetings and healthcare issues (Mpungose, 2021). The pandemic has also forced the organisations to adapt work from home (WFH) and online collaborations tools gain popularity (Gottipati et al., 2021). When employees are working from home, there are many implications like reduced business travels, fewer real estate requirements, compact office politics, flexible scheduling, care for family, increased productivity etc. The increased productivity of employees means more comfortable workplace, fewer interruptions, more focused time, quitter work environment and avoiding office politics

(Choudhury et al., 2021). Looking all such advantages, it seems that this work culture is not just a temporary substitution but will be a permanent shift with more reliance on the online collaboration tools (Lata and Gupta, 2021). Work engagements for some occupations like higher education, software industries, insurance, social networking etc. can see permanent shift to such tools (Kumar and Bhardwaj, 2020b). An online collaboration is established using tools which are web-based technologies and platforms that help teams to connect worldwide. Such tools support different means of communication like chat, live messaging, file sharing, screen sharing, audio and video conferencing. Some commonly used online collaboration tools are Zoom, Microsoft Teams, Google Meet, Cisco Webex, Bluejeans, GoToMeeting etc. Beside pros, online collaborations have cons as well like it increases information vulnerabilities to viruses, worms and spywares as time spend on devices for work using internet has increased. Also there may be some systems flaws generated by online collaboration tools which may allow an attacker to access the system and lead to breaches like security, privacy and trust during online collaboration (Bhardwaj and Kumar, 2021). Flaws may be due to design, hardware, human factor and bugs in the program.

Figure 1 Online collaboration with cloud platform



2 Work from home (WFH)

The COVID-19 pandemic has changed the workspace dramatically with 2020 seen as the year of remote work and the trend continued for 2021 as well (Bonacini et al., 2021; Purwanto et. al., 2020). This is a situation where employees are not physically present at the work place of their employers or the customer of their service (Bhardwaj and Cyphert, 2020). The pervasive accessibility and ease of use for online collaboration tools such as Zoom, GoogleMeet, Microsoft Teams, Cisco Webex etc. have enabled people to quickly and smoothly adapt to WFH environment. Most of the technical work is possible to be done by employees from their home or any location. Only the work which cannot

be done remotely include working on hardware devices or data centers. As per Statista, 30% of the employees are doing WFH and their productivity has increased due to working from home (https://www.statista.com/topics/6565/work-from-home-and-remote-work/). As per PwC (PricewaterhouseCoopers), organisations have supported their employees to work in new pattern with safety and wellbeing guidance, tips for working from home, tools to carry out tasks efficiently etc. (https://www.pwc.com/mt/en/publications/the-covid19-remote-working-experiment-final4.pdf). The FlexJobs survey has also reported that 94% of the employees wish to continue WFH post pandemic, either full time or in a hybrid environment. For doing so, they are willing to compromise 10–20% cut in salary as well and agreed to be more loyal to their employees for providing flexible work options (https://www.flexjobs.com/blog/post/survey-productivity-balance-improve-during-pandemic-remote-work/). Gartner surveyed organisation leaders regarding their intentions over flexible working post COVID-19 pandemic where 82% agreed to allow their employees to work remotely some of the time with flexible days and hours (https://www.gartner.com/en/newsroom/press-releases/2020-07-14-gartner-survey-reveals-82-percent-of-company-leaders-plan-to-allow-employees-to-work-remotely-some-of-the-time). As per Kurtessis et al. (2017) employees expect organisations to support them in time of need as one who cares for their values and welfare for their contributions. In the same directions, organisations are also supporting their employees to do WFH in different ways during COVID-19 pandemic. Organisations are providing special emotional and mental health programs for their employees wellbeing, support for child care assistance etc. Several physical reporting and other obligations have been removed by organisations to support WFH. Some of the other initiatives from different organisations are mentioned in Table 1.

Table 1 Support for work from home (WFH) by different organisations

S. No.	*Company*	*Support for work from home* (*WFH*)
1	Dream11 (www.dream11.com/)	Gaming unicorn Dream11 is implementing a doorstep delivery of goodies to cheer up their employees by the planned 'seasonal surprises'. Employees are paid extra allowances to pay for increased internet and electricity bills
2	Facebook (www.facebook.com/)	The company allowed employees to WFH with adjusted salaries as per their location of home from where they will be working. The company also organised regular in-person meetings, get-together for remote workers and office workers to support relationship building. Company is also optimistic to large scale remote work due to improved video conferencing and virtual reality tools
3	Feather (www.livefeather.com/)	A furniture rental company provided add-ons to its employees by US$100 for office supplies, US$25 weekly for food while at home, 25% of Wi-Fi bill and payment for purchasing additional computer hardware like head phones, web-camera, keyboard or mouse
4	Google (www.google.com/)	Provided its employees with US$1,000 in May, 2020 to support work-from-home gear. To address WFH burnout, the company has also announced TGIF (Thank God its Friday) an official day off on May 22 to do something that prioritise employees well beings

Table 1 Support for work from home (WFH) by different organisations (continued)

S. No.	*Company*	*Support for work from home* (*WFH*)
5	PepsiCo (www.pepsico.com/)	The company is supporting its employees by providing child care assistance through in enrolling for summer camp at their cost. This educational program spans from science to theatre to cooking
6	Razorpay (www.razorpay.com/)	The company is supporting their employees with high-speed internet connection and a no-question-asked allowance to set-up office at their home. It has also partnered with brands offering ergonomic furniture to make employees life easier
7	Siemens (www.siemens.com/)	Germany's Siemens has relaxed timings of work for their employees for only two to three days of the week whenever reasonable and feasible. The company has allowed employees to work from a place wherever they are most productive like from home or from a co-working place
8	Twitter (www.twitter.com/)	The company supported WFH by announcing no business travel and no in-person business events during pandemic with only few exceptions. The company is doing a reimbursement of home office set up expenses, day-care expenses to support parents. Also, introduced #FlockTalk for social gatherings and messages from leaders
9	Virgin Atlantic (www.virginatlantic.com/)	The company has deployed knowledge library for their employees to stay informed about new guidelines and government regulations for COVID–19, This helps to keep formal information centralised, sharing real time news and to keep employees morale high

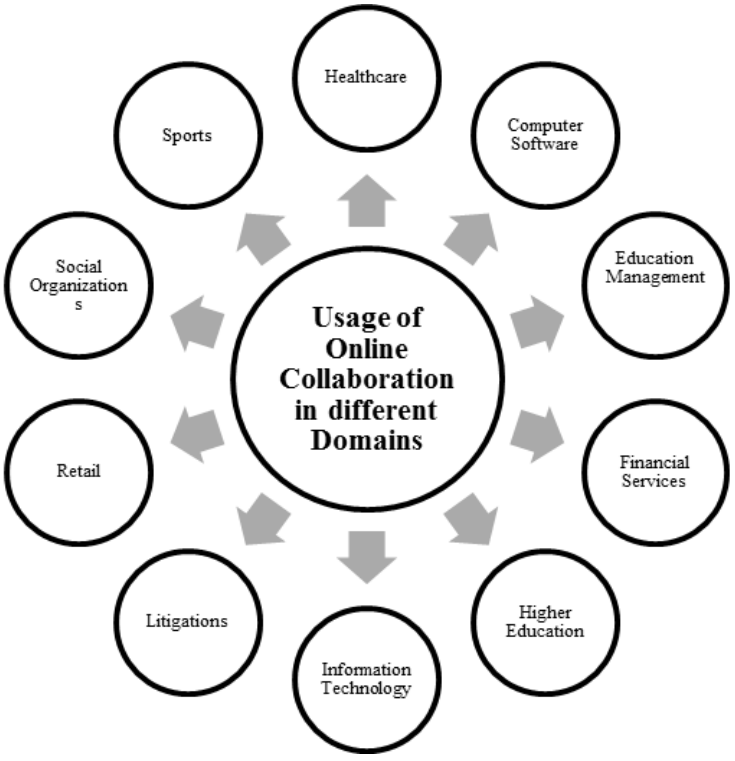
3 Usage and breaches during online collaboration

The users in online collaboration do their tasks together in real time by coordinating, communicating, cooperating, sharing, negotiating and competing with each other. There are numerous uses of online collaboration in brainstorming, project management, visualisation, prototyping and communication (De Boer et al., 2021). Some of the common uses of online collaboration in different areas with their specific objectives have been presented in Figure 2.

In computer software domain the online collaboration helps to hire best talent and expand remote workforce without concern to where they live in the world. Provides a cost effective and appropriate substitute to in-person interviews which provides high-quality and qualitative alternative. No version control issues, email chains, lost messages and delays. Also, the technology is convenient and easy to use, enhances personal interface, accessible through mobile phone, tablets, laptop or computer and saves time with no travel requirements (Gray et al., 2020; Tyagi and Rekha, 2020). In education management online collaboration improves degree of understanding as human's process visual information better than audio or text. Hence used extensively in teaching students in K-12 schools, Colleges and Universities. Also helps in providing sufficient guidance to young students, more online opportunities to adolescents and additional learning to senior students (Yan et al., 2021; Francis and Sreenath, 2019). In the domain of financial

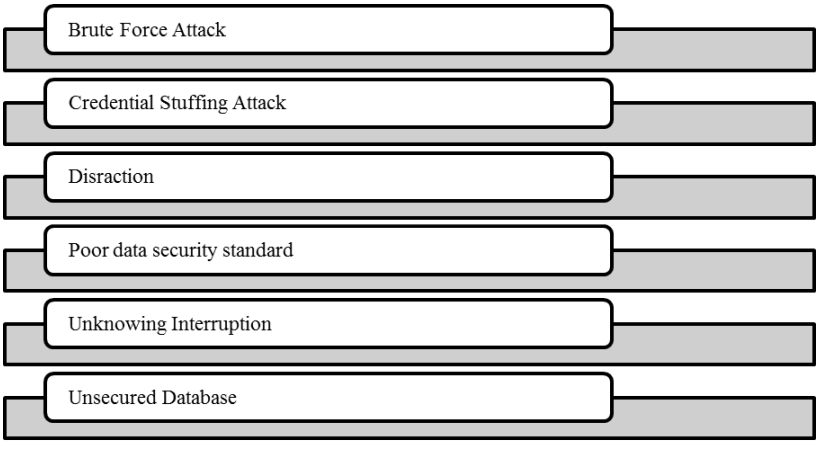
services online collaboration works as a helpful tool in building relationships and connect on a personal level. The feature to record and transcribe online video meeting helps to keep records intact. These can be referred back to answer the questions raised and share the session with those who were not able to attend. The tools of online collaboration help to effectively evaluate insurance payments, operational risks and reporting documents optimisation (Aguayo and Ślusarczyk, 2020; Bhardwaj and Kumar, 2022b). Online collaboration has benefitted the domain of healthcare in different areas like tele-consultation, training of staff for new equipment, kits etc. Specialist advice available easily for diagnosing patients in remote locations. It is used for psychotherapy which is a feasible and acceptable treatment for individuals and families. Also, used for medical science education, digitalised hospital processes, knowledge management for medical professionals and new IT initiatives for healthcare sector (Yan et al., 2020). For higher education domain online collaboration has provided the freedom to join through any device, scheduling face-to-face meetings and keeping everybody updated is easier. Academics and Research collaboration and thesis presentations are made easier using internet based tools. This can even be advanced to international online collaborations where students can be benefitted from cultural diversity, project management, leadership, communication and technology use (Kolm et al., 2021; Bhardwaj and Kumar, 2022a). In the domain of information technology online collaboration encourages punctuality and focused discussion. Use of tools like screen sharing, real-time document editing helps all team members to examine the files and contribute in discussion. It is also helping customers to receive personalised solutions, contents and expertise in real time. This is achieved by use of augmented reality and location based mobile applications (Nwinyokpugi and Taribo, 2020; Parise et al., 2016). Also, globally courts have shifted to online proceedings due to COVID-19 pandemic which reduces intimidation of vulnerable court witnesses, particularly in sensitive or criminal cases where victim can be physically separated from the court. Also, helping anticipated rise in litigations in healthcare due to novel corona virus. These conditions are helping courts to move for online collaborations where they can guarantee liberty, social order, resolve disputes, maintain rule of law and to ensure due process of law (Sourdin et al., 2020; Tyagi et al., 2019). For the domain of retail as more participants from remote locations can participate to contribute inputs. All feedbacks get incorporated with questions answered immediately. Cost savings on travel, accommodation and staff timings. Reduces bunch of messages, barrage of misperception and makes complete team work on same guidelines faster. The technology helps to preserve the privacy of users and shares them with audio-video with its benefits (Neustaedter et al., 2020; Bhardwaj and Kumar, 2022d). In the domain of social organisation online collaboration helps in making human connections irrespective of physical locations which improves decision making and speeds up ability to globally collaborate. It help in remote staff training; helps to deliver collaborative in-person experience in simple way without expenses on travel. Unique advantage of bringing human connection through face-to-face communication (Marhefka et al., 2020; Bhardwaj and Kumar, 2022c). In the sport domain online collaboration helps in receiving expert guidance for training and nutritional advice from experts. Helps to hold training sessions, webinars, product launches for athletes around the world. Also, increases collaboration of sports persons with researchers and statisticians for exercise science, medicine, physiotherapy etc. to improve performances during sports event (Sainani et al., 2021).

Figure 2 Usages of online collaborations in different domains



With the increasing use of online collaboration, especially during COVID-19 pandemic, the world has seen many incidents of breaches leading to distraction, unknowing interruption, credential stuffing attacks, poor data security standards etc. An incident of breach due to brute force attack using online collaboration is reported by WhiteHat Jr an educational company helps to improve coding skills of young children. An incident of data breach exposed data of 2.8 lakh students and teachers in November 2020. The exposed data contains salary details of employees, recorded videos of online classes and internal documents. The exposed data also contains progress report of students, their names, age, gender, profile photo, parents name and user ids (https://www.zeebiz.com/technology/news-top-8-data-breaches-that-happened-during-covid-pandemic-full-list-143958). In the category of credential stuffing attack during online collaboration is reported by Zoom, a video conferencing platform faced a major cyber-attack in April 2020, with more than 500,000 Zoom account passwords stolen. These passwords along with victim's meeting URLs and host keys were available for sale in dark web crime forums. During these attacks hackers use bots to hammer sites with automated attempts to login using data from past breaches. Once the bot hits right combination, the data is compiled into a list of previous stolen credentials and offered to sale (https://www.forbes.com/sites/leemathews/2020/04/13/500000-hacked-zoom-accounts-given-away-for-free-on-the-dark-web/). Figure 3 presents some of the prominent categories of incidents related to usage breaches, which happened during online collaborations.

Figure 3 Categories of incident breaches during online collaborations



In the category of distraction during online collaboration is reported with 'Sun Bae' a hacker who entered a Pakistan online class pretending to be Zoom official for securing the class. Then again entered by fantasising to be an official from Board of School Education helping students. He became the host of the meeting and removed the teacher first followed by removing many students and distracting the complete class (https://www.youtube.com/watch?v=7bJwYCagMNE). In the category of poor data security standard during online collaboration is reported by Clearview AI a main company dealing with facial recognition technology became a victim of data breach due to internal and unintentional instances. The main reason was poor data security standard because of which perpetrators gained unauthorised access to entire client list. The data breach compromised the number of user accounts opened by clients, number of searches they have conducted and photos scrapped by the company from social media like Facebook, Youtube and Instagram (https://www.cnet.com/news/clearview-ai-had-entire-client-list-stolen-in-data-breach/). In the category of unknowing interruption during online collaboration a businessman was spotted taking a bath during Zoom meeting with Brazil President Jair Bolsonaro. The meeting was organised by Federation of the Industries of the State of Sao Paulo. The incident was noticed by the president when an official forgotten to switch off the camera while taking a bath during conference. The official concerned is not being identified yet (https://www.indiatoday.in/trending-news/story/man-spotted-taking-a-bath-during-zoom-meeting-with-brazil-president-jair-bolsonaro-1679463-2020-05-19). In the category of unsecured database during online collaboration the Virgin Media database which contains details of 900,000 users was accessible for ten months before being discovered leading to data breaches. This happened due to unsecured database which was incorrectly configured by a staff member. The database contained important information regarding phone numbers, residence address and emails which were used for marketing purposes by the company (https://www.bbc.com/news/business-51760510).

4 Framework for online collaboration

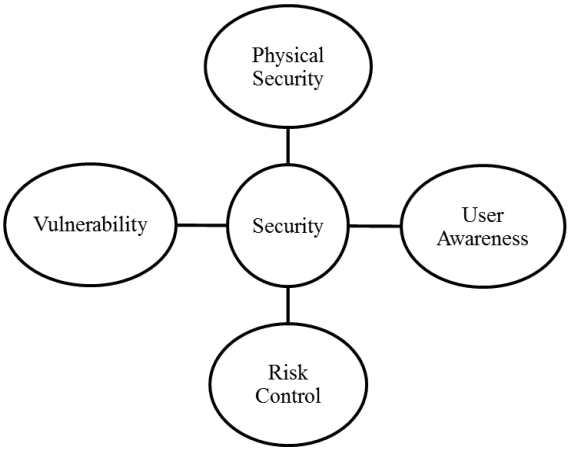
Online collaboration is established using internet technologies which is different from traditional collaborations. It connects wide number of participants whose performances is much better than their individual enactment (Strauß and Rummel, 2021). Online collaborations are often challenging and leading to breaches for security, trust and privacy (Themelis and Sime, 2020). For online collaboration high security standards are essential which do not allow unauthorised participants to join the meeting and protects user data as well (Hasan and Hasan, 2021). Trust in online collaboration is another important factor which helps in building confidence and dependence of a user (Barley, 2021). It is also a measurement of degree to which team members in an online collaboration rely to enforced security, cryptography and reputation of the platform. The online collaboration platform Zoom has become a de facto standard during corona virus era used by schools, businesses, support groups and millions of individuals for working in remote world (Secara, 2020). The zoom is being hit by breaches leading to trust of users due to online abuses initially regarded as trolls or pranks later outstretched to the level of hate speech and harassment commonly referred to as zoom bombing. As per Lorenz and Alba, 2020 zoom bombing or zoom raiding refers to the incident of unwanted or disruptive intrusion where a session is hijacked by a zoom raider. The session is inserted with materials which are obscene, racist, or homophobic in nature leading to mostly shutdown of session. The video recording of such sessions is some time uploaded on social media like TikTok or YouTube as well. Such incidents are not limited only to zoom platform but are observable on other online collaboration platforms like Webex or Skype as well (https://handwiki.org/wiki/Social:Zoombombing). Ministry of Home Affairs, Government of India has cited that Zoom, an American video conferencing platform is 'not safe for video conferencing'. Further MHA has issued guidelines and suggested security configurations for those who still want to use zoom regardless of the loopholes (https://www.thehindubusinessline.com/info-tech/mha-issues-guidelines-for-using-zoom-app-says-not-safe-for-video-conferencing/article31356296.ece). Privacy is another important factor of concern during online collaboration which leads to disclosure of unprotected user data, selling of user data to third parties and video hijacking (Williams et al., 2021). Privacy concerns are very high as it is found that online collaboration providing companies shares data of users on social media with third parties like Facebook, LinkedIn etc. (Graffi and Masinde, 2021). The collected data is also shared sometimes to work with Google and to other advertising companies which further turn them into personally targeted advertisements to reach customers (Kumar et al., 2021). These breaches happen mostly in the free version of these platforms which are allowed with restricted access to small businesses and personal use only.

4.1 Security

Security during online collaboration requires contributions from all the participants in order to diminish the effects of breaches and avoiding incidents of fissures (Bhardwaj and Kumar, 2011). There are many incidents leading to security breaches during online collaboration leading to financial losses, loss of reputation and trust (Khalil et al., 2021). Some of the tips to secure online collaborations include enabling passwords for all the meetings, validating participants at the start of meeting and to review participants during

the call as well (Dong et al., 2021). Factors affecting security breaches for users during online collaborations are shown in Figure 4.

Figure 4 Factors affecting security during online collaboration



Factors affecting security are physical security, vulnerabilities, risk control and user awareness. Physical security is an important factor during online collaboration leading to security breaches which includes cloud based technology, workflow management tools, visual representation of workflow and ability to track participant's foot prints (Antheunis et al., 2020). Risk control is an important factor for security during online collaboration for which organisations need to establish strategies specific to their business for eliminating threats (Sheng et al., 2020). Organisations should carry out debriefing meetings regularly to sensitise their employees regarding security risks, security tips and organisation policies while working during online collaboration. This also includes educating employees with cyber security practices, updating machines to latest software, destroying data before disposal and using a strong data leak prevention system. As a risk control strategy organisations should identify the digital assets like computers, software, systems, networks or data and should take stock of the most valuable ones on priority basis. Vulnerability is associated with unintentional security threats like Amazon web Services buckets and outright attacks like Denial of Service or Ransomware attacks (Andrew, 2020). Awareness of employees for working securely and increasing productivity from wherever they are located should be the priority of organisations (Jalali et al., 2021). Host of the meeting should keep the camera in switch on mode for identification to participants and may use virtual background to hide environment and add rumour. Precautions should be kept for shared links of online collaboration to protect against malicious scams. Also, proper reporting for any suspicious activity should be done to desired authority dealing with security especially in times of social distancing. As per Gray et al. (2020) for preventing security breaches during online collaborations some best practices to be followed includes keep updated system in place, use of advanced encryption standards, single sign on (SSO) Authentication. Domain security which suggests that online collaboration should not connect without firewall and should not enable automatic answering of incoming calls (Buja, 2021). Also suggest a strong policy for online collaboration in place by the organisation. End-to-end encryption

(E2EE) method is one of the important requirements for securing online collaboration which prevents any unassociated third parties and service providers to access the messages during digital communication from sender to receiver (Bai et al., 2020). Using this encryption method the data is encrypted at sender's device or system and is decrypted only at intended recipient.

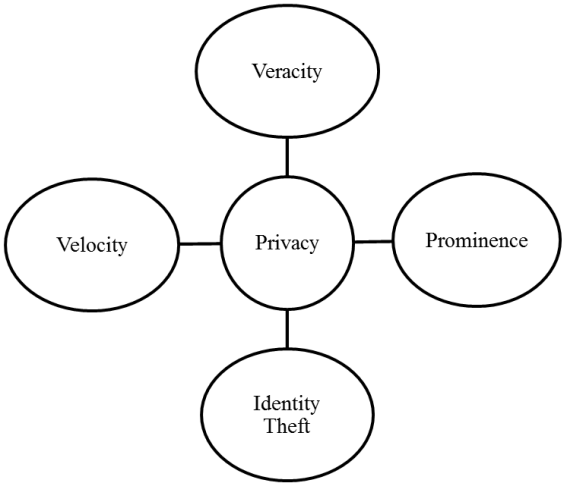
4.2 Privacy

Privacy issues arise during online collaborations as participants are sometimes able to view other people user's name, job title, location and organisation they belongs to without taking permission or even notifying the user (Lobe and Morgan, 2021). Some common measures for participants of online collaboration to prevent privacy breach incidents include source authentication, cross-checking before sharing and comparing information with other media (Tayal and Bharathi, 2020). Factors affecting user's privacy during online collaborations include veracity (legitimate or fraud), prominence (importance), velocity and identity theft (Bhardwaj and Kumar, 2014). As per di Bella, (2014), 'Veracity refers to the biases, noise and abnormality in data' It refers to trustworthiness of data which may make result from the analysis completely futile if not correctly composed and preserved. Velocity is the speed at which new data is generated. It is found that rumours are transmitted quickly and before legitimate information in most of the incidents like in Boston Marathon Bombing (Yifan et al., 2021). It is found by MIT (Massachusetts Institute of Technology) News in other incidents as well like COVID-19 pandemic that false news travel faster, farther and deeper than true stories mostly on social media like Twitter (https://news.mit.edu/2018/study-twitter-false-news-travels-faster-true-stories-0308). This happens because people repost or re-tweet the inaccurate news items and is not because of bots which are programmed to propagate incorrect stories (Vosoughi et al., 2018). Untruthful news travels faster because it is novel and people are excited to share novel information as others respond with astonishment and antipathy (Kim et al., 2019). Privacy policy of the third party which will be used for online collaboration is very important. Prominence is an important factor constituting privacy during online collaboration which informs users about the policies of service provider regarding the collection, usage and revelation of personal data (Kuem et al., 2020). The personal data includes cookies and usage data along with demographic detail like email, name, age, address and contact number. It is examined Krämer and Zierke (2020) that people pay less attention to prominence and prefer free contents through dominant platforms or app stores. Factors affecting privacy during online collaborations are shown in Figure 5.

Such organisations after collection of personal data gathers revenues later from the contents collected from the users. For protecting privacy sensitive information like IP addresses, trade secrets, passwords, business data etc. should not be exchanged on online collaboration platforms (Bhardwaj and Kumar, 2021). One should not accept unauthorised online collaboration invitations which my serve as a Trojan horse from some hackers. It is a common practice to send meeting invitations which contains viruses or malwares (Bayazit et al., 2020). Disabling cookies and working from a quiet place during online collaboration are good practices to prevent data gathering methods to collect data about users (Barrett and Murphy, 2021). Otherwise personalised advertisements of products are targeted for example if a baby cries in the background or pet pops up on screen, after some time related advertisement pops up in side bar (THEN,

2021). Also, the organisations have a requirement to comply with different privacy laws like General Data Protection Regulation (GDPR) or California Consumer Privacy Act (CCPA) or India's Personal Data Bill, 2019 (PDP Bill).

Figure 5 Factors affecting privacy during online collaboration

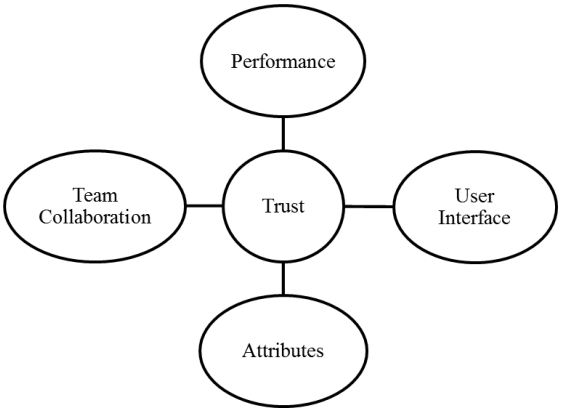


4.3 Trust

Challenges faced by teams working during online collaboration across different fields can be overcome by trust. Trust is overall a critical success factor for online collaboration which improves performance, coordination, knowledge sharing and cooperation (Newcomb et al., 2021). Factors affecting trust during online collaborations are shown in Figure 6.

Factors affecting trust during online collaborations include performance, attributes, user interface and team collaborations. Factors affecting trust during online collaborations are shown in Figure 5. Source of information, close proximity, real time news, posts by competent person, posts by relative or friend (Tayal and Bharathi, 2020). User interface for establishing trust is very important as it provides ease of use with informational, functional and non-classified categories during online collaboration (Nagaraj, 2021). Informational category for establishing trust includes secure transaction, personal data protection, website recommendation, participant's feedback and their tracking facility from platform providing company (Wang et al., 2021). Functional category for trust establishment includes easiness in platform navigation, its performance and handling participant's protection. Non-classified category for establishing trust includes assurances, accreditation, competitiveness, credibility, transparency and usefulness (Baten and Hoque, 2021). There are many benefits of using online collaboration platform to participants however they can fulfil their potential only if they are able to gather trust of participants. For gaining trust performance is one of the key factors influencing during online collaboration (Castelli and Sarvary, 2021). Attributes for trust during online collaboration includes accountability, competency, trusted third party, ease of navigation, availability and business brand name (Dalley et al., 2021; Fan and Zhang, 2020).

Figure 6 Factors affecting trust during online collaboration



5 Online collaboration and Industry 4.0

Industry 4.0 is the Fourth Industrial revolution which is using modern technologies for automation of manufacturing and industrial practices (Zheng et al., 2021; Erboz, 2017). This current trend of Industry 4.0 uses smart technologies for real time data exchange which provides enormous opportunities to re-shape the conventional business operations (Ali et al., 2021). The nine significant pillars of Industry 4.0 are as shown in Figure 7.

It has many benefits like improving customer's experience and better return on investment opportunities. Also, it helps to improve productivity, efficiency, provides flexibility, agility and increased profitability (Wagire et al., 2021). The nine pillars of Industry 4.0 are Additive Manufacturing, Augmented Reality, Autonomous Robots, Big Data and Analytics, Cloud Computing, Cyber Security, Industrial Internet of Things, Simulation and System Integration (Rosin et al., 2020; Lavingia and Tanwar, 2020; Vaidya et al., 2018). Additive manufacturing commonly defined as 3D printing is a pillar to Industry 4.0 which refers to producing customised goods as per requirements from customers. 3D printing includes techniques to reduce air craft weight by using titanium as a raw material, acceleration for smart phone activities, increase mass customisation and staying agile. This helps in ensuring maximum machine availability and reliability at the same time minimising the usage of materials for maintenance and repairs (Goh et al., 2021). Next pillar to Industry 4.0 is augmented reality which enables harmony between virtual worlds and its users with real surroundings. It enhances human machine interaction, visual control on physical objects and remote inspection of maintenance tasks. It supports workers in Industry 4.0 environment by making use of technologies like digital information for hardware and software components (Marino et al., 2021). The usage of autonomous robots in areas such as production, logistics and distribution activities to solve complex tasks accelerates with Industry 4.0. Such robots are having capabilities to learn like humans, check and optimise the tasks with the help of cloud systems problems, developing new ventures for handling large documents and developing new innovative business models (Bousdekis et al., 2021). The data analytics is to analyse large datasets to find customer's preferences, trends, algorithms for correlations for fault predictions and reducing error probabilities (Wang et al., 2020). Cloud computing brings various advantages to Industry 4.0 such as facilitation

management, administration, atomisation and integration. It visualises the resources and provides services three different models. Software as a Service (SaaS) helps customers for softwares, Platforma as a Service (PaaS) provides access to applications for software developers and Infrastructure as a Service (IaaS) offers storage services like Google Drive from Google, Windows Azure from Microsoft and Blue Cloud from IBM (Rana and Sharma, 2021). Next pillar is cyber security which is associated with availability, confidentiality and integrity of associated data with Industry 4.0. It deals with defensive systems and preventive solutions against security, privacy and trust breaches. This includes analysis of critical assets to be protected which is correlated to its business impact on organisation leading to competitive advantage (Corallo et al., 2020). Industrial internet of things is crucial for effective decision making and operational agility. It refers to solutions for computations and analytics based on data collected from physical objects and relying cloud systems (Munirathinam, 2020). Simulation tools play a supportive role in Industry 4.0 activities by real time optimisations and promoting sustainable manufacturing environment. Such tools have the ability of self-configuration, ability to adjust in complex systems, accurate estimations about the system, helps to acquire real time data and enable effective shop floor management (Enrique et al., 2021). System integration refers to horizontal and vertical systems integrations which includes flexible reconfiguration and integration of partners. This coordination creates framework for smart factory which is self-organised structure and is cloud based through shared platforms (Nara et al., 2021). Industry 4.0 relies on real-time data, machine learning, autonomy, automation and interconnectivity for transferring physical world into digital creation of everything connected (Munirathinam, 2020). Some of the ways like innovative capabilities, consistent data, ergonomics settings, reduce costs, quality control, environment protection, occupational safety, flexibility and agility (Fields et al., 2021; Li et al., 2021). Online collaborations benefit Industry 4.0 to enable real-time decisions, increase revenue, productivity and efficiency. Other benefits of online collaboration to Industry 4.0 includes reduce costs incurred on travelling of employees from one location to another. Infrastructure costs of maintaining locations of work place for employees are reduced as they can WFH at their locations. Employees can use ergonomics settings for their working place which could be personalised and not the used in traditional offices for general employees (Broday, 2020). This increases the comfort of individuals which increases their efficiency, productivity and reduces discomfort. The innovative capabilities of workers are increased through online collaboration which augments Industry 4.0 through combined efforts of all the participants. Through online collaborations organisations ability to identify new ideas and transform them new products, services or processes is improved. Consistent data another intensification from online collaboration to Industry 4.0 as same data is used by all the participants of online collaboration (Pang et al., 2021). The Online collaboration augments Industry 4.0 in different ways as shown in Figure 8.

This is very important as computing confidence intervals or conducting hypothesis tests is a desired property for different transactions. Online collaborations helps Industry 4.0 in quality control through four different ways like process control, control charts, product quality control and process control. These help to speed up the learning process and make appropriate decisions through Artificial Intelligence and Machine Learning. Industry 4.0 is associated with rapid pace of digitisation in manufacturing today which requires operational safety as well. This is achieved by the use of online collaboration which helps manufacturing processes and techniques which are evolved by it

(Rauch, 2020). This helps businesses to improve their production, output and performance. Online collaboration aids Industry 4.0 to combat climate change by enabling circular economy, use of resources within closed loop and achieve sustainable development through eco-innovations (Tortorella et al., 2021). Flexibility and agility attained through online collaborations supports Industry 4.0 to work in partnership with customers, manufacturers, suppliers and other parties in the supply chain. This helps to improve competitiveness, transition to digital economy, opportunity to achieve economic growth and sustainability (Contador et al., 2020).

Figure 7 Nine significant pillars of Industry 4.0 (see online version for colours)

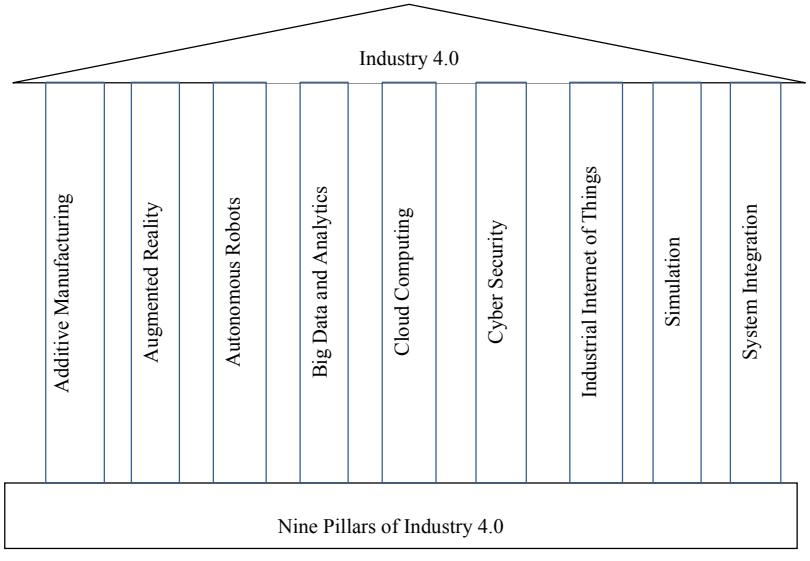
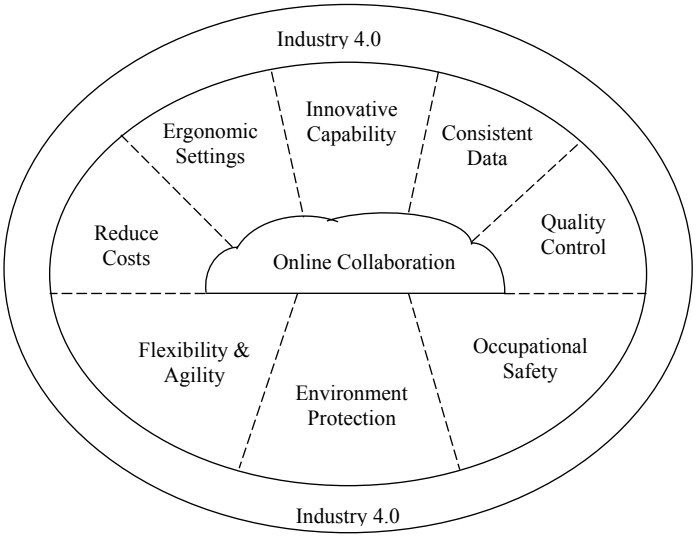


Figure 8 Online collaboration augments Industry 4.0



6 Conclusion

Online collaboration is a promising solution in different areas like education management, healthcare, sports, computer software, retail, information technology, financial services, social organisations and litigations. One of the main applications of online collaborations is in promoting WFH which has gained popularity since world has implemented lockdowns to prevent spread of COVID19 pandemic. As the popularity increased the incidents of breaches also increased due to fraudsters attempting brute-force attack, credential stuffing attacks due to poor security standards, unsecured database leading to distractions and unknown interruptions. This paper presents a framework for factors affecting user's security, privacy and trust during online collaboration. The factors for security includes vulnerability of online collaborations, participant's awareness, physical security of systems and risks control measures implemented. The factors affecting user's privacy includes truthfulness of data which is veracity, velocity of data which is mostly slow for legitimate information than false information, identity theft by fraudsters and prominence of data. The factors affecting user's trust include performance of platform providing organisation for online collaboration, team work during collaboration; user interfaces for platform and attributes to online collaboration. Based on the platform delivered in the paper, users can defend themselves from security, privacy and trust breaches. Online collaboration is also augmenting Industry 4.0 through its applications which are the current trend to re-shape conventional business operations, improve productivity, efficiency, profitability and flexibility.

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