**Abstract**

Adaptive automation refers to process in which both the user and the system can initiate changes in the level of automation. The first adaptive automation systems were implemented in associate systems based on models of user’s behaviour and workload. Recently, however, systems have been developed that follow the neural networks approach and use Artificial Intelligence measures to trigger changes in the state of automation. Studies suggested that this approach can facilitate user performance. Further, evidence is beginning to show that people not only think of adaptive systems as co-workers, they may even *expect* them to behave like humans.

Adaptive automation creates new challenges for both users and designers that go beyond traditional ideas of human-computer interaction and system design in run time dynamic network storage cloud.

**Introduction**

The adaptive automation focuses on current research and developments in the neuroscience of information processing called as Neural Networks and Artificial Intelligence and how that knowledge can be used to improve performance in real-world environments with computing systems or information processing with cloud Storage.  Here we need to understand that how the brain processes perceptual and cognitive information can lead to better designs for equipment, systems, and tasks by enabling a tighter match between task demands and the underlying brain processes similar way by using techniques of AI and neural networks Computing systems can process information to store and retrieve data at run time dynamic networked cloud and fetch as and when required.. Ultimately, research in this area can lead to safer and more efficient working solutions.

            Ironically, interest in neural networks and Artificial Intelligence evolved from research surrounding how operators interact with a form of technology designed to make work and our lives easier – automation.  In general, automation is a computing system machine agent capable of doing tasks normally performed by a human being. For example, In a Software Testing environment, either Software testing is done manually or it’s done using some tools and technique using automation designed to reduce task demands and workload. And it allow individuals to increase their scope of operation or control, perform functions those are beyond normal abilities, maintain performance for longer periods of time, and perform fewer mundane activities.

Automation also helps to reduce human error and increase safety.

Research on human interaction with automation concludes that it does not always make the job easier. Instead, it *changes* the nature of work.

“Automation changes the way activities are carried out and can introduce new and different types of problems.  Automation can lead to different types of errors because user system goals may be inconsistent with the goals of systems and subsystems where subcomponents of system are tightly coupled, some weird problems may propagate more quickly and be more difficult to isolate. In addition, highly automated systems leave very less activities for user systems or humans to perform. Consequently, the user becomes a more passive monitor instead of an active participant. It’s shown that this shift from performing tasks to monitoring automated systems can actually inhibit one’s ability to detect critical signals or warning conditions. Further, a user (Technical Person) manual skills can begin to deteriorate in the presence of long periods of automation “

**Adaptive Automation**

            Given the problems associated with automation noted above, researchers and developers have started to find and develop alternative methods for implementing automated systems. Hence idea of *Adaptive automation* developed which has been proposed to address shortcomings of traditional automation. In adaptive automation, the automation level and/or the number of systems operating with automation can be modified dynamically in real (run) time.

“Additionally changes in the state of automation can be initiated by *either* the human (User) or the system (Computing Devices). Consequently, adaptive automation enables the level or modes of automation to be tied more closely to user needs at any given moment”

            Adaptive automation systems can be identified as either *adaptable*or *adaptive. “I we talked about* taxonomy of adaptive technology. One side of this taxonomy concerns the underlying source of flexibility in the system, i.e., whether the information displayed or the functions themselves are flexible. Another side addresses how the changes are invoked.”

In **adaptable** systems, user initiates the changes in the allocation of functions. However, in **adaptive** systems both the user and the system can initiate changes in the state of the system.

            The distinction between adaptable and adaptive terminology can also be described with respect to authority and autonomy.

“There are several levels of automation that range from completely manual, to semiautomatic, to fully automatic.”

With the increase of level of automation, systems adapts more authority and autonomy and at the lower levels of automation, systems by pass autonomy to the user. The user either reject or accept the suggestions and then implement the action.

At moderate levels, the system have the autonomy to process with the suggested actions accepted by the user. And in the end at higher levels, the system may decide on a course of action, implement the decision, and merely inform the user.

Hence higher level of autonomy is expected with system called as run time dynamic adaptive systems.

“With respect to Scerbo’s (2001) taxonomy, adaptable systems are those in which the user maintains authority over invoking changes in the state of the automation. On the other hand in adaptive systems, authority of invocation is shared. Both the user and the computing system can initiate changes in state of the automation.

            There has been discussions having control among modes of operation.  Some argue that users should always have authority over the system because they are ultimately responsible for the behaviour and performance of the system.

In addition, it is possible that users may be more efficient at managing resources when they can control changes in the state of automation.

Many of these arguments are based on work with critical systems related to security of data in which safe and secure operation is of utmost concern.  There may be times when the user is not the best judge of when automation is needed. i.e. changes in automation may be needed at the precise moment the user is too busy to make those changes.

“It can be shown mathematically that the best decisions concerning whether to abort a data transfer are not those where either the human or the Data Center maintain full control? Instead, the best decisions are made when the user and the automation share control.

     Some critical situations where the user system is vulnerable, it would be extremely important for the system to have authority to invoke automation. If situations are at stake or the system is in jeopardy, allowing the system to intervene and circumvent the threat or minimize the potential damage would be paramount. For example, it is not uncommon for many of today's data center/cloud to sustain high bandwidth enough to fulfil high demands. These Conditions make a strong case for system-initiated invocation of automation.

**Adaptive Strategies in run time dynamic systems**

 Let’s discuss about strategies by which adaptive automation can be implemented.

One set of strategies addresses system functionality in which entire process may be allocated to either the system or the user (It may be another system), or a specific task can be divided so that the system and user (client or server) both share responsibility for unique portions of the task.  Alternatively, a task could be transformed to a different format for the user system to perform.

 A second set of strategies is related to the triggering mechanism for shifting among modes of automation. This is a goal-based strategy. In this, levels of automation are triggered by a set of criteria depends on external events/forces.  Thus, the **run time dynamic** system invoke the automatic mode only during specific tasks or in an emergency situation. Another approach would be to use real-time measures of user systems performance to invoke the changes in automation.

A third approach uses models of user system’s (client or server) performance or workload to drive the adaptive logic in run time dynamic systems.

For example, a system could estimate current and future states of a user’s activities, intentions, resources, and performance.  Information about the user, system, and the outside world could then be interpreted with respect to the user’s goals and current actions to determine the need for adaptive aiding. Finally, measures that reflect system workload can also be used to trigger changes among modes.

**Examples of Adaptive Automation Systems**

            Adaptive automation has its beginnings in artificial intelligence.  In the 1970s, efforts were made toward developing adaptive technologies to help allocating and organizing tasks between humans and computing systems.

By the 1980s, researchers began developing adaptive interfaces. For instance, Wilensky, Arens, and Chin (1984) developed the UNIX Consultant (UC) to provide general information about UNIX, information about executing/running UNIX commands, as well as debugging/analysing information. The UC could analyze user queries/questions, confirms the user goals, monitor the user’s interaction history with system, and present the system’s response for better performance. These methodologies are used now a days in business like online shopping to check user interests.

**Workload and Situation Awareness**

***Workload****.* One of the arguments for developing adaptive automation is that this approach can moderate user’s system workload.  Most of the research till date has assessed workload through primary task performance. To perform a simulated task where the object was to send data to targets without colliding with one another.  During manual control, the user were required to assess the situation on the display, make decisions about which targets to eliminate, and implement those decisions. During a shared condition, the user and the computer could each perform the situation assessment task. The computer scheduled and implemented the actions, but the controller had the ability to override the computer’s plans. The users were also asked to perform a secondary task requiring them to monitor the movements of a pointer and correct any deviations outside of an ideal range.  The secondary process used to invoke the automation on the primary process. For half of the participants, the computer suggested changes between automation or manual operation of the primary task and for the remaining participants, those changes were mandated.

            In data storage cloud network shared control resulted in better performance than manual control on the primary task. The results showed that compulsory use of automation also improved performance during periods of manual operation. Regarding the secondary task, when use of automation was mandated, data processing workload was lower during periods of automation; however, under periods of manual control, workload levels actually increased and similar to those seen when its use was suggested.  It comes out that authority over invoking changes between modes had differential effects on workload during periods of manual and automated operation. Specifically, it’s found that the requirement to “consider” computer suggestions to invoke automation led to higher levels of processing workload during periods of shared/automated control than when those decisions were dictated by the computer.

***Situation awareness.*** As per the study of the effects of adaptive automation on situation awareness. Situation awareness is the ability to perceive elements in the environment, understand their meaning, and to make projections about their status in the near future.  One might assume that efforts to moderate workload through adaptive automation would lead to enhanced situation awareness; however, that relationship has yet to be demonstrated empirically. In fact, within an adaptive paradigm periods of high automation could lead to poor situation awareness and make returning to manual operations more difficult. .

Effects of the adaptive conditions were moderated by complacency potential. Specifically, for individuals in the control conditions, those who were high as compared to low in complacency potential had much lower levels of situation awareness. On the other hand, there was no difference in situation awareness scores for high and low complacency individuals in the adaptive conditions. More important, the situation awareness scores for both high and low complacency individuals were significantly higher than those of the low complacency participants in the yoke control condition. The authors argued that a brain-based adaptive automation system could ameliorate the effects of complacency by increasing available attentional capacity and in turn, improving Situation Awareness.

**Human-Computer Etiquette**

            There has been interest in the merits of an etiquette for human-computer interaction for the requirements of adaptive automation. Etiquette is a set of prescribed and proscribed behaviours that permit meaning and intent to be ascribed to actions. Etiquette makes social interactions more cooperative and polite. Importantly, rules of etiquette allow one of form expectations regarding the behaviours of others. People generally adopt many of the social terminologies used in human-human interactions when they interact with computers.” Moreover, they also expect computers to adhere to those same conventions when computers interact with users.

            When humans interact with computing systems that incorporate intelligent agents/subsystems they may expect those agents to conform to accepted rules of etiquette. However, the norms shall be contextually dependent: what is acceptable for one application may violate expectations in another. Hence, there may be a need to understand the procedures under which automated computing systems should behave in expected polite way.

            There might be expectations regarding human etiquette to their interactions with adaptive automation. It’s been observed that much of the dialog between team members in a data centre environments was focused on communicating plans and intentions. Any automated component would need to communicate in a similar manner to be accepted as a “team” player. Consequently, the described earlier was designed to allow users and the system to communicate in a conventionally accepted manner.

             The benefits of adopting a human-computer etiquette are described in a study of human-automation interactions in adaptive data storage environment. In particular, they focused on interruptions. Participants were asked to perform the tracking and resource management tasks from the storage devices. Another task required participants to interact with an automated system that monitored system parameters, detected potential failures, and offered advice on how to diagnose faults. The automation support was implemented in two ways. Under the “normal” condition, the automated system would withhold advice if the user was in the act of diagnosing the system or provide a warning, wait few seconds, and then offer advice if it determined the user was not interacting with the system. Under the “extreme” condition the automated system offered/popped its advice without warning while the user was performing the diagnosis. The normal and extreme automation as examples of good and poor etiquette, respectively. additionally, they examined two levels of system reliability. Under low and high reliability, the advice was correct 70 and 30 percent of the time, respectively.

            As expected, performance was better under high as opposed to low reliability. Further, it’s been found that when the automated system functioned under the good etiquette condition, operators were better able to diagnose system performance regardless of reliability level. Additionally overall levels of trust in the automated system were much higher under good etiquette within the same reliability conditions. Thus, “rude” behaviour made the system seem less trustworthy irrespective of reliability level. Several participants commented that they disliked being interrupted. The Systems designed to conform to rules of etiquette may enhance performance called as system reliability.

            Findings gathered with a high criticality simulated system; however, the rules of etiquette (or interruptions) may be equally important for business or home applications.   In a recent study, they examined the effects of different levels of communication on task performance with a simulated adaptive interface. Specifically, stakeholders worked with a computer system “partner” to solve problems (e.g., determining the shortest mileage between two cites or estimating gasoline consumption for a trip) using a commercial travel planning software package.  In their study, the computer operator was actually in another room who followed a strict set of rules regarding how and when to intervene to help complete a task for the participant. In addition, they followed four different modes of communication that differed in the level of restriction ranging from context sensitive natural language to no communication at all.  The results showed that as restrictions on communication increased, participants were less able to complete their tasks, which in turn, caused the computer intervene more often to complete the tasks. This increase in interventions led the participants to rate their interactions with the computer operator more negatively.  Hence, these findings suggest that even for less critical systems, poor etiquette makes a poor impression. Apparently, everyone like real performance and ground work even if it is the computer or any automated system incorporating artificial intelligence.

**Managing Dynamic (Run Time) Adaptive Automation of Storage Cloud.**

            Adaptive automation is finding its way into commercial and more common technologies of day to day activities. Few examples include adaptive control found on several high-end automobiles and “smart homes” that control electrical and heating systems to conform to user preferences. Also in Managing Data Center and Cloud storage systems and accessing data as and when required. And not it reached the in the hands of every individual being in the form of smart phones.

There are experiences of an adaptive Data Center or Cloud Storage. The Data center is designed to regulate Information processing in a fast and secure way.  The automation monitors the data transfer activities and makes inferences about the data patterns behaviour, predicts future needs, and adjusts the bandwidth or speed accordingly. Here when the automation fails to meet the user’s expectations, the user can set the controls manually.

            The heart of the adaptive Data Storage (or Cloud) is the adaptive control of data center environment and functions to balance two goals: user desires and provide data as and when required instantly without any delay. Because these goals may conflict with one another, the system uses a reinforcement learning algorithm to establish an optimal control policy. The ACCE (Adaptive Control of Cloud Environment) encompasses a learning controller that selects settings based on current states of demand. The controller receives information about triggering of event that is supported by a cost evaluator. A state estimator generates high-level information about inhabitant patterns and integrates it with output from an occupancy model as well as information regarding levels of data available to make decisions about changes in the control settings. The state estimator also receives input from an anticipator module that uses neural nets to predict which zones are likely to be inhabited within the next seconds.  Thus, if the data is moving within the center, the ACCE can anticipate the route and adjust the data before it arrives at its destination.            Hence there may be some observations about experiences with adaptive Data center and cloud. First, there will be a hypothetical model of the ACCE’s.  There is a conscious effort to be more consistent in data transfer activities developed a meta-awareness of patterns and recognized behaviour more regular, it facilitated the operation of the ACHE, which in turn, helped it to save energy and maximize service of data access.

            Here the value of communication should be understood. Whenever a bug is noticed in the hardware then system should be modified to broadcast a warning message throughout the Data Center to reset the system. After the hardware problem had been addressed, the warning message should be retained because it provided useful information about what was happened. There may be situations where the user could benefit from being told about consequences of manual overrides.

**Benefits of Run Time Dynamic Adaptive Automation**:

* Cross Browser/OS testing independent of a user's machine
* Testing against older versions of browsers
* Real mobile device testing for mobile web and native apps, both iOS & Android
* Visual Validation for softer "look and feel" testing
* Ability to define test scripts in plain English and translate to any Programing Language code
* Test result reports including screenshots of failed test cases
* Execution from Windows & OSX or Linux desktops
* Execution from CI platforms such as Jenkins & Bamboo

**Cross Device Testing Automation**:

There are automation tools that allows you to run application on multiple platforms and saves a lot of time.

As these automation tools are Time and effort saving but still manual intervention is required because these tools cannot test the usability and accessibility of applications.

Emulator Software: to perform cross platform and environment testing, emulator need to be virtualization. Virtual machine need to be created with different environmental combinations as well as emulator are used to check behavior of applications.

# **What Is the Adaptive Network?**

The Adaptive Network is an approach that expands on autonomous networking concepts to transform the static network into a dynamic, programmable environment driven by analytics and intelligence.

Since the introduction of the first Public Switched Telephone Network, networks have continually evolved and now a days it reached to the level of Software Defined Networking.

There are various stages of development from fixed endpoints to today’s broadband networks that connect mobile users to massive data centers and bandwidth behemoths i.e. Amazon, and Facebook have grown/scales to accommodate continuous demands.

Static infrastructure is going through a profound transformation than ever before. The latest product is autonomous networking with Data Center, which is a trend that has been building from few years. Hence autonomous network runs without much human intervention, it can configure, monitor and maintain itself independently.

Even though it’s a significant advance, autonomous adaptive networking is still needs much attention and development with Artificial Intelligence. Hence further approach is defined to the evolution of networking with the Adaptive Network that’s toward providing a network that can scale with a organizations as their business needs and markets change.

### Adaptive Network Vision

The Adaptive Network is reinvention the network into a dynamic, programmable infrastructure built on analytics and dynamic automation.

The Run Time Dynamic Adaptive Network allows organizations to evolve their current infrastructures into more of a communications loop that relays information from network elements, instrumentation, users, and applications to a software layer for action, rather than blaming the network itself.

**The Adaptive Network includes three important layers**:

* **Programmable infrastructure:** This includes the physical and virtual elements of network, as well as the related components gathered from them. The adaptive infrastructure layer should be highly intelligent and interprets data so the network can make decisions, whether that means routing traffic around a network that's down or investigating and correcting an issue with delay on a targeted site. Adaptive infrastructure needs a flexible grid; a reconfigurable photonic layer to give the ability to reroute channels of variable spectral occupancy across any path, and across any spectrum in the network from the IP layer correlated with forwarding data. In addition, an adaptive infrastructure needs tunable coherent transponders to efficiently map a flexible number of client signals to the variable line capacity. In turn, that requires a centralized purpose-built architecture.
* **Analytics and intelligence:**The programmable infrastructure produces massive amounts of data. Big data indicate trends that the network learns and adjusts for over time and approach towards to automated adaptive network. Big data can trigger the network on how to coordinate in the long term, which traffic patterns to look out for, and which parts of the network could be vulnerable. Even with small data things are happening at a fairly fast pace. It could be an urgent request from a customer. Such important events needs a speedy response from the Data Center network, so those moves can be made by the analytics. Hence once the decisions are made, a human operator or pre-defined policies could step in and approve or change things as necessary. In an actual autonomous network, there would be no external influence but a full adaptive approach.
* **Software control and automation:** It’s been found that one cause of network outages is human error. Effective automation of network tasks, such as loading access controllers and provisioning routers, or automated calculation and configuration of tunnels to optimize data traffic and relieve congestion,can eliminate those errors and keep the adaptive network running at peak performance. The ability for adaptive automation to work across multiple sites is critical. Few technologies are good at working with one set of devices from a single vendor, but some networks are built on a single vendor’s system. But Networks have to interoperate, using defined APIs, to function efficiently and move data efficiently and swiftly from point to point.

The development of the Adaptive Network is a significant movement for the Data Storage Networking world. Adaptive automation is a cohesive evolution that supports all aspects of intelligent automation, such as intent-based, analytics, and programmable domain control with Artificial Intelligence. It’s a micro services-based architecture that delivers extensibility and scale, and it takes an Operations integration approach to provide operational and service agility.

The Adaptive Network is an approach that expands on autonomous networking concepts to transform the static network into a dynamic, programmable environment driven by analytics and intelligence on network storage cloud.

# **An Adaptive Data Storage Network can solve today’s challenges.**

The key aspects of the Adaptive Network, as traffic increases and becomes less predictable, effective partnerships will become more critical. As network management conditions are difficult for carriers, with legacy network limitations; and intense competition from new market entrants and evolving business models. An agile and adaptive network can help operators overcome these challenges; and exploit the emerging opportunities like IoT and 5G users.

There is a push-pull from rapid business and technology change affecting users today. On one hand, dramatic growth in subscriber demands are driving front haul and backhaul traffic and putting networks under intense pressure. There’s a wide race to develop and commercialize revenue-generating services, such as IoT use cases and 4G-5G mobile services, and to implement the network technologies and architectures needed to support and deliver them. Further new market entrants, including internet companies, are deploying massive-scale network connections that support low-cost data transport between key locations and data centers with unrivalled economies of scale.

The challenges for users are; to take continuously traffic growth in stride; then to prepare the network for the next-generation of Inter of Things and next generation use cases; and then to remain competitive on price with large connectivity providers in the market.

**Uses of Adaptive Adaptive Network:**

**1) To Increase network agility and efficiency** – because the Adaptive Network turns the simple network into an automated, dynamic, programmable infrastructure built on analytics and automation, it helps meet growing bandwidth needs with on-demand scalability. As well as helping users to handle incremental traffic growth and unpredictable demand peaks, an Adaptive Network supports real-time scaling and resource-allocation to support differentiated Quality of Services for different applications and use cases, way for commercial next Generation services.

The agility of an Adaptive Network also helps operators to maximize efficiency by automating a wide range of manual networking processes, from routine service provisioning and turn-up, to resource discovery and traffic routing over the best available components and paths. So it helps users compete effectively with even the largest connectivity providers.

**2) Future-proofing the network with industry leading packet-optical solutions – few organizations** created the industry’s most scalable portfolio of programmable, packet-optical network infrastructure to help operators meet massively growing bandwidth demand up to the edge.  Our packet-optical solutions cover the metro edge, between data centers, the backbone core, and submarine. This packet-optical market leadership, enabled by consistently high R&D investment, is based on our deployed 100G, 200G, and 400G capable in-house modem technology, supported by a unique combination of software intelligence to get the best of optical innovation to the market.

Leading technology portfolio supports continuous convergence of voice and data traffic for mobile operators. This allows operators to integrate 4G and 5G traffic in the future, and delivers it extremely cost effectively across a unified infrastructure.

By ensuring that the network can keep pace with exponential increases in bandwidth demands and new services requirements (low latency, high availability) our packet-optical portfolio protects our clients’ business for the long-term.

**3) Helps to avoid vendor lock-in with open networking -**Many network providers design their portfolios to work together, however, infrastructure is becoming increasingly complex, needing to integrate components and processes in multi-vendor environments. This approach requires large-scale “lift-and-shift” infrastructure upgrades which are costly and disruptive, as well as reducing ROI on existing network equipment.

To maximize cost efficiency and value for clients, the portfolio of hardware and software are designed on the principle of openness. This allows operators to tie an entire network infrastructure together into a single environment that delivers value for the business and end-customers long-term.

As well as integrating all equipment both legacy and new, can help monitor and manage multi-vendor networks with a centralized, integrated set of tools. This capability is delivered to Manage, Control and Plan (MCP) software, which gives full visibility of resources and services across multi-vendor domains, with tools to troubleshoot and manage diverse infrastructure components remotely.

**4) Driving network innovation in strategic partnership** - Finally, but equally importantly, Ciena is a strategic partner for global operators. Based on our financial and operational stability, we are able to commit to continual innovation of our portfolio, ensuring that our clients can embrace emerging opportunities and take future network challenges in our stride.

One example of how we are investing for the future is our recent acquisition of Packet Design, with network performance management software that is focused on Layer 3 network optimization, topology and route analytics. By integrating Packet Design into Blue Planet, we will be able to extend our intelligent orchestration and automation capabilities from layer 0, 1 and 2 into the IP layer. As a result, our clients will be able to further optimize service delivery and maximize resource utilization – taking the Adaptive Network to the next level.

**Adaptive Interface to Scalable Cloud Storage:**

Many of today’s applications are delivered as scalable, multi-tier services deployed in large data centres. These services frequently leverage shared, scale-out, key-value storage layers that can deliver low latency under light workloads, but may exhibit significant queuing delay and even dropped requests under high load.

**Scalable Cloud Storage** is a system that helps these applications adapt to variation in storage-layer performance by treating scalable key-value storage as a shared resource requiring congestion control. Under light workloads, applications using **Scalable Cloud Storage** send requests to the store immediately, minimizing delay. Under heavy workloads, Stout automatically batches the application’s requests together before sending them to the store, resulting in higher throughput and preventing queuing delay. We show experimentally that **Scalable Cloud Storage** adaptation algorithm converges to an appropriate batch size for workloads that require the batch size to vary by over two orders of magnitude. Compared to a non-adaptive strategy optimized for throughput, **Scalable Cloud Storage** delivers lower latency under light workloads; compared to a non-adaptive strategy optimized for latency, **Scalable Cloud Storage** can scale to many requests.

**Conclusion**

The development of adaptive automation represents a qualitative leap in the evolution of technology. Users of adaptive automation will be faced with systems that differ significantly from the automated technology of today.  These systems will be much more complex from both the users’ and designers’ perspective. Adaptive automation systems will need time to learn about users and users will need time to understand the automation. User and his data center needed some time to adjust to each another.  Further, users may find that adaptive systems are less predictable due to the variability and inconsistencies of their *own*behaviour.  Thus, users are less likely to think of these systems as tools, machines, or even traditional computer programs. Any adaptive Data Storage Center would respond to demand.  **Hence interacting with adaptive systems is more like interacting with a teammate or co-worker**

The challenges facing designers of adaptive systems are significant. Current methods in system analysis, design, and evaluation fall short of what is needed to create systems that have the authority and autonomy to swap tasks and information with their users. These systems require developers to be knowledgeable about task sharing, methods for communicating goals and intentions, and even assessment of operator states of mind.   Researchers and designers of adaptive technology need to understand the organizational, and behavioural patterns that impact communication and teamwork among humans to create more effective adaptive systems. In this regard, ideas regarding human-computer interactions may be a mile stone to the development of successful adaptive systems.

            Thus far, most of the adaptive automation systems that have been developed address life critical activities where the key concerns surround the safety of the operator, the system itself, and recipients of the system’s services. However, the technology has also been applied in other contexts where the consequences of human error are less severe (e.g., Adaptive Data Storage Cloud). Moreover, adaptive automation could be particularly useful when incorporated in systems aimed at training and skill development as well as entertainment.

To date, most of the adaptive automation systems that have been developed were designed to maximize the user-system performance of a single user. Thus, they are user independent (i.e., designed to improve the performance of any operator).  However, overall user-system performance is likely to be improved further if the system is capable of learning and adjusting to the behavioural patterns of its user. Although building systems capable of becoming more user-specific might seem like a logical next step, that approach would introduce a new and significant challenge for designers of adaptive automation – addressing the unique needs of multiple users. The ability of Data Storage Cloud to successfully adapt to demand patterns is due in large part to his being the only inhabitant. One can imagine the challenge faced by an adaptive system trying to accommodate the wishes of two people who want the temperature set at different levels.

The problem of accommodating multiple users is not unique to adaptive automation. In fact, the challenge arises from a fundamental aspect of humanity. People are social creatures and as such, they work in teams, groups, and organizations. Moreover, they can be co-located or distributed around the world and networked together. Developers of collaborative meeting and engineering software realize that one cannot optimize the individual human-computer interface at the expense of interfaces that support team and collaborative activities.  Consequently, even systems designed to work more efficiently based on knowledge of brain functions must ultimately take into consideration groups of people. Thus, the next great challenge for the neuroergonomics approach may lie with an understanding of how brain activity of multiple operators in social situations can improve the organizational work environment.