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The Impact of Real User Monitoring (RUM) on Digital Transformation in the Utilities industry

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Abstract
The utilities industry is undergoing major digital transformation. Digital platforms such as web applications and mobile applications are increasingly used to serve customers with important functionalities such as customer portals, outage management systems, customer support, etc. With heavy adoption of digital platforms, real user monitoring (RUM), is important to understand how users interact with the applications. This paper explores the key challenges faced by the utilities industries, such as reliability and performance during peak/ storm conditions, user adoption of new functionalities, and improving the user experience across various touch points. This paper also explores integration of real user monitoring with observability tools which provide comprehensive health overview of the application.

Keywords: Real User Monitoring, Observability, Digital Transformation, Telemetry, Utilities Industry, Service Level Agreement, Application Performance Management, Application Performance Index (Apdex), Session replay, User Experience (UX), Smart Grids, AI, Machine Learning, Operational Efficiency, Customer Engagement

Introduction

The utilities industry is undergoing a massive digital transformation. To better understand the transformation, an understanding of the phrase digital transformation is required. Digital transformation is the process of integrating technology into the core operations of a business. This has the potential to increase efficiency and improve customer experience [3]. The utility companies are modernizing their infrastructure to include smart grids, IoT devices, and customer facing platforms. With these changes, the complexity of their technology stack is growing exponentially. This complexity makes it difficult to stay on top of the performance and user experience.

Real user monitoring (RUM), has emerged as one of the most important observability technologies available to help maintain and increase user satisfaction. Traditional monitoring focuses on the health of the infrastructure. Whereas real user monitoring provides visibility into how the users interact with an application or a website. This provides actionable insights into the performance bottlenecks, errors, and engagement patterns.

This paper explores the positive impact of real user monitoring in addressing challenges faced by the companies in the utilities sector. Real user monitoring empowers the organizations to maintain reliability, performance, and customer satisfaction during critical situations like storms. It also aids in compliance with strict service level agreements and regulatory requirements [2], helping providers maintain trust and reliability in a very competitive market.

By integrating real user monitoring with advanced observability practices, utility companies can connect a user interaction issue with more contextual back-end details. This will enhance the organization’s ability to not only understand the user experience but also be able to identify the root-cause of the issue and resolve it quickly. This paper also explores the advantages of integrating real user monitoring with advanced observability practices and some practical applications where this integration can be valuable.

Key Terminology

A. Real User Monitoring

Real User Monitoring (RUM) is a method used to observe and analyze how actual users interact with websites or applications.

B. Utilities Industry/ Sector

The utilities sector includes companies that provide essential services such as electricity, natural gas, and water. Because of their essential nature, utility companies typically operate in highly regulated environments.

C. Digital Transformation

Digital transformation is the process of using digital technologies to transform business processes and services to meet with evolving market and customer expectations.

D. Service Level Agreement (SLA)

Service Level Agreement is a contract between the service provider and its customers. It defines the level of service the customer expects from the service provider. SLA identifies specific metrics through which the service is measured. The SLA also outlines the remedies or penalties in case the expected service levels are not met.

E. Observability

Observability is the ability to understand the current health and state of a system by analyzing the data (metrics, logs, and traces) it generates.

F. Application Performance Management (APM) Tools

Application performance management/ monitoring tools are a set of tools that are designed to help IT professionals ensure that applications meet the user's expectations in terms of performance and reliability.

G. Application Performance Index (Apdex)

Application Performance Index or Apdex score is an open standard quantitative metric that measures how satisfied users are with the performance of a web application or a service.

H. Session Replay

Session replay is an observability tool that replays a user's journey on a web application or a mobile application to see how the user interacts with the product.

I. Telemetry

Telemetry is an automated process of measuring and transmitting data from remote sources.

J. PurePath

PurePath is Dynatrace's patented distributed tracing and code-level analysis technology.

Literature Review

The utilities industry is undergoing a major digital transformation. This transformation is driven by adoption on new digital technologies that transform how energy and resources are generated, distributed, and consumed. The increase of integration of devices such as smart grids and IoT devices are greatly improving operations, customer engagement, and sustainability [1][8].

The paper on digital transformation enabled by Internet of Things [1], highlights the shift in business processes from product centric to data-driven service models. The paper emphasized the importance of ado-

pting a holistic approach to IoT implementation, which is purely technology-driven [1].
Similarly, in [2] the author also emphasizes the importance of digital transformation in the utility industry. They explain the benefits public utility companies stand to gain with digital transformation. The study explores the reengineering of one of the core processes of the utility company. Where new technologies are used to cover functional needs which bring several operational optimizations [2].
With the massive raise in data produced through digital transformation, Real user monitoring (RUM) has gathered increased attention among industry researchers, focusing its role in providing reliable, efficient, and user-centric services. Several studies have focused on the role of real user monitoring in supporting digital transformation, particularly in complex industries like the utility industry.
The author in the paper "A Concept Lattice for Recognition of User Problems in Real User Monitoring", explores the difficulty in identifying user experience problems encountered while using a software product. The paper further dives into the usage of real user monitoring to identify, understand, and resolve these problems [7].

Digital Transformation in the Utilities Industry

The utilities industry like other industries is undergoing a massive digital transformation. This transformation is driven by few key factors.

A. Evolving customer expectations

More customers are preferring to interact with the utility companies via digital platforms such as web portals, mobile applications, etc. [3]. With these interactions, the customers also expect seamless, fast, and reliable experiences. There is also an increase in demand for features such as real-time energy consumption tracking, personalized recommendations, instant updates during outages, and quick customer service interactions. To meet these expectations, the utility companies need to adopt advanced digital solutions that can handle traffic and deliver consistent performance. Figure 1 below shows an example of a mobile app that helps track energy consumption in real-time [5].

Figure 1 shows an example mobile app that helps track energy consumption in real-time

B. Decentralized energy systems

With growing emphasis on green energy, the utility companies are seeing a shift towards decentralized energy systems [6]. This includes the usage of renewable energy sources such as solar, wind, and hydro. This is transforming the traditional utility model. Utility companies now have to manage a complex network that not only includes traditional utility network but also distributed energy resources (DERs) and "Prosumers" (customers who are both producers and consumers of energy). Figure 2 below shows a network map of decentralized grid, with solar panels, wind turbines, homes connected to substations [6].

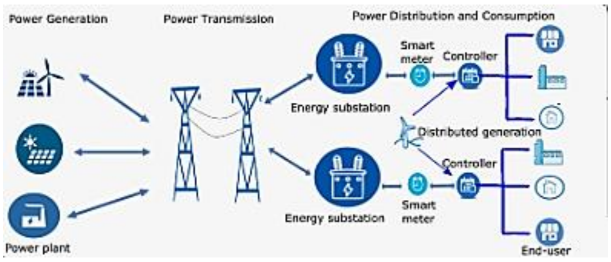

Figure 2 shows a network map of decentralized grid, with solar panels, wind turbines, homes connected to substations

C. Regulatory compliance and sustainability goals

The utility providers must adhere to strict standards with regards to environmental impacts, reliability, and customer service. Failure in following these standards could result in heavy penalties and fines [2]. Regulatory compliance requires robust observability solutions, that can ensure satisfactory uptime, performance, and security. And, to meet the sustainability goals the utility companies would need to integrate with green technologies [6]. Balancing these objectives add multiple layers of complexity to the IT landscape in the organization.

D. Technological advancements

The adoption of advanced technologies has the potential to revolutionize the utilities sector. IoT devices such as smart meters and grid sensors provide real time data on energy consumption [4], grid performance, equipment health, etc. allowing utility companies to monitor and optimize their systems proactively [1]. Smart grids allow integration with renewable energy sources, bi-directional energy flow management, and demand fluctuation response [4][8]. AI and machine learning further empowers utility companies by giving them the ability to predict equipment failure, identifying energy saving opportunities, detecting anomalies, and automating the decision-making process. Together these technologies increase the operational efficiency and customer satisfaction of the utility companies. Figure 3 below shows an illustration of smart grid ecosystem [8].

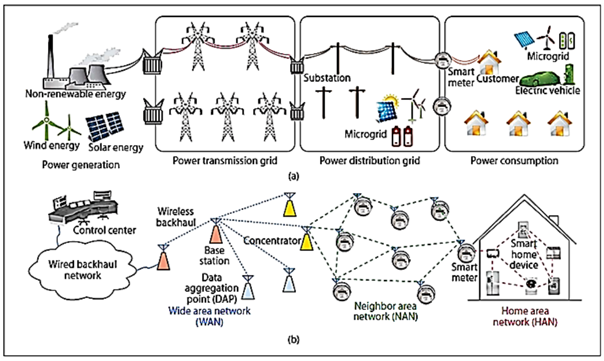

Figure 3 shows an illustration of smart grid

Complexities Introduced By Digital Transformation

Enabling digital transformation in the utilities industry introduces many advanced technologies such as IoT devices, smart meters, cloud computing, and AI [8]. Although these technologies are exceptional at optimizing operational efficiency and customer experience, they also significantly increase the complexity of the IT systems. Below are few key factors contributing to this increased complexity.

A. Increased system connectivity and data volumes

Digital transformation has led to massive interconnectivity between systems with IoT devices, smart meters, grid sensors, etc. sending vast amounts of data across the network every day [1][4]. Although these

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devices help the utility companies to optimize their operational efficiency and improve customer experience, they also add significantly to the complexity of the IT landscape. With the influx of large amounts of data, ensuring data accuracy, performing analytics on the data to enable real-time decision making becomes very difficult. To accomplish this, Artificial Intelligence (AI) and Machine Learning (ML) are introduced. This further complicates the IT infrastructure as hosting AI and ML is resource intensive and needs specialized expertise.

B. Complex modern architecture

Many utility companies still rely heavily on legacy systems, these systems are not designed to work with modern digital technologies. Integrating these legacy systems with modern architectures such as cloud-based solutions and micro services offer scalability and flexibility. But this integration could be complex to deploy and manage. Managing these environments where cloud and on-premise systems co-exist is extremely complicated and requires specialized expertise.

C. Cybersecurity challenges

Integration of new digital technologies such as IoT devices, smart meters, and grid sensors introduces new cybersecurity threats. Introducing these new devices, increases the attack surface. This makes ensuring the security of these new technologies very crucial. Utility companies must use multi-layered security strategies to protect against hacking, data-breaches, and ransomware attacks while complying with strict regulations.

D. Dynamic regulatory compliance

The utilities industry must adhere to ever-evolving and stringent regulatory frameworks. These regulations often require organizations to meet strict standards for reliability, security, customer service, environmental impact, etc. The responsibility of monitoring, generating detailed and accurate reports to prove adherence also falls on the utility companies. These standards are often tied to service level agreements (SLAs), which could mean heavy monitory penalties if the standards are not met [9]. Figure 4 below shows an example dashboard showing real-time monitoring of SLA metrics, regulatory compliance indicators, etc.

Figure 4 shows automated SLA Monitoring dashboard

How Can Real User Monitoring Help

Real user monitoring (RUM) is a powerful tool that provides utility companies the ability to monitor and understand user experience and behavior. By capturing real user data organizations could understand how users interact with their applications, identify performance bottlenecks, errors, etc. This offers actionable information to improve both reliability and user satisfaction.

A. Enhance user experience

Real user monitoring (RUM) helps track how users interact with web and mobile applications of an organization. Understanding how users experience their applications help organizations identify performance bottleneck and errors that create an unfavorable experience for the users. The organizations can use these insights to focus on removing performance pain points and greatly improve the user experience.

Real user monitoring can also be used to understand the intuitiveness of an application, by showing if parts of the webpage are easy to access. If a user is having to search for an option on a webpage for too long this could cause the user to lose interest and move away from the webpage. This could mean loss of business and poor reputation. Organizations can use these data point to redesign webpages making them easy to use and more intuitive. Figure 5 below shows user experience metrics on a dashboard.

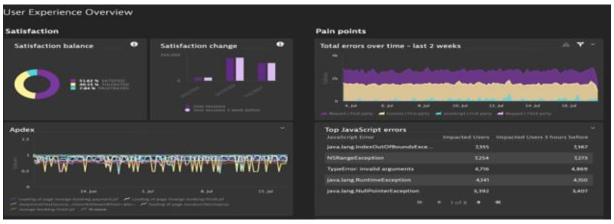

Figure 5 shows user experience monitoring dashboard

B. AI-driven proactive issue detection

By monitoring the user interactions with the application in near real-time, real user monitoring captures the data needed to identify anomalies. Integrating this data into a robust AI engine could help identify anomalies which deviate from the baseline pattern. AI engine creates a baseline and understands normal behavior of different elements of an application, For example, if a page loads slower than normal or if a request is facing more errors than normal, the AI engine could correlate this data to backend data and proactively identify an issue before it starts impacting the users.

C. Smart managing of peak demand

Utility companies face high demand situations like storms or extreme weather from time to time. Real user monitoring can help monitor the user behavior during these traffic spikes, ensuring the users are able to access and get response from critical functions such as outage reporting etc. Real user monitoring in conjunction with robust full stack monitoring, can identify situation where additional resources are needed, and trigger APIs to scale up or scale down the resource ensuring the services are performing as expected.

D. SLA and compliance monitoring

Often, utility industries must meet strict regulatory and compliance standards and these conditions are generally bound by SLA contracts [2]. Not adhering to these regulatory standards would mean heavy penalties for the organizations. Real user monitoring can help track such conditions via metrics such as latency, availability, error rate, and application performance index (apdex). These SLAs can be converted to Service Level Objectives (SLO) and can be monitored proactively. The SLOs can be used to generate proactive alerts in case of potential SLA breaches [9]. This can help organizations to stay on top of their SLAs and avoid heavy fines or negative impacts [9].

E. Enhancing security and anomaly detection

As real user monitoring tracks user behavior in near real time, it can detect unusual user behavior patterns that might indicate potential security threats, such as fraudulent activity or attempts to exploit vulnerabilities. By integrating real user monitoring data with cybersecurity tools utility companies can identify and alert on unusual activities in real time, correlate user activity to backend monitoring data to identify known attack patterns. Being able to proactively identify such attacks, organizations can take pre-ventive measures to secure their systems and protect users' data.

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F. Improving operatinal efficiency

Real user monitoring provides a holistic view of user interactions, helping utility companies understand the most impactful issues to the users. With the help of this data provided by real user monitoring, organizations can make data-driven prioritizations to enhance their customer experience and trust [5].
By integrating real user monitoring with AI-driven observability tooling, organizations can proactively identify issues, allowing them to efficiently use resources to avoid problems and reduce reactive IT interactions [7].

IMPLEMENTATION OF REAL USER MONITORING

Several industry-leading monitoring tools provide real user monitoring or RUM functionality. Depending on the type of application, the RUM integration differs. In most cases, the RUM is instrumented by either integrating a lightweight script, or an agent, or a software development kit (SDK), to the application.
In case of web application, most of the tools require a JavaScript to be injected into the code of the application. For example, New Relic requires an addition of a JavaScript snippet into the “<head>” section of the web application’s HTML pages. Whereas in case of AppDynamics, the RUM can not only be instrumented by placing the JavaScript snippet in the header section of the HTML, but it can also be instrumented by adding the script to either the NGNIX configuration file or to an adrum.conf file, which in-turn can be included in the httpd.conf file.
Dynatrace, like AppDynamics provides multiple ways of instrumenting RUM. The recommended approach is by installing an agent on the server that is hosting the application. This will automatically inject the JavaScript snippet to the webpages. If installing an agent is not possible, then a JavaScript snippet can manually be added to the header to the web page as well. Figure 6 shows an example of JavaScript snippet autoinjected into an application by Dynatrace.

```
<script type="text/javascript" src="/ruxitagentjs_ICA
```

Figure 6 shows Dynatrace JavaScript agent auto injected into a web application

Unlike web applications, instrumentation of RUM on mobile applications is similar between multiple tools. Almost all tools offer either a SDK or a plugin, which the developers can integrate into their code to enable real user monitoring of the mobile applications. Let’s consider Dynatrace as an example, Dynatrace provides options to instrument monitoring for multiple flavors of mobile applications. The instrumentation for each of the flavor slightly vary but the end integration would function similar. In case of hybrid apps, a Cordova plugin can be used. The steps of instrumenting monitoring for a hybrid app using Cordova plugin would be as follows:

1. Add the cordova plugin to the root directory.
   cordova plugin add @dynatrace/cordova-plugin –save
2. Select “monitor web view”.
3. Download the Dynatrace.config.js file from Dynatrace UI and place it in the root of the cordova app workspace next to the config.xml file.
4. Build the project using cordova build android or cordova build ios commands.

Figure 7 below shows the cordova instrumentation screen in Dynatrace

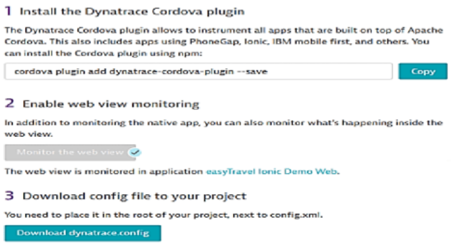

Figure 7 shows the cordova instrumentation screen

INTEGRATING REAL USER MONITORING WITH OBSERVABILITY TOOLS

Real user monitoring provides very valuable information regarding user experience and user behavior while interacting with an application. But the value of this data can be exponentially increased by integrating RUM with full stack monitoring data. While RUM focuses on the user interactions and front-end performance, full stack monitoring can correlate and extend the visibility to backend services, infrastructure, database, and network layers. This allows organizations to analyze the root cause of a front-end slowness all the way down to the code that is rendering the front-end.

Distributed tracing is a common method of integrating real user monitoring (RUM) with backend data. Here are some examples of tools and how they achieve full stack and RUM integration.

A. Dynatrace

Dynatrace injects a unique identifier on the browser side using the JavaScript snippet and corresponding backend calls using the agents. These unique identifiers are used to integrate real user monitoring with the backend data and allow full stack traceability.

B. New Relic

New Relic uses a similar approach, where the JavaScript agent injects a TraceId to the browser requests and when these requests are propagated to the backend server, it allows the platform to link the frontend events to the relevant backend operations.

C. AppDynamics

AppDynamics also uses unique identifiers from frontend to backend. In case of AppDynamics these identifiers are called as "business transaction IDs".

Datadog, Elastic, and Splunk use similar distributed tracing technology as wellto corelate real user monitoring data with backend monitoring data. Figure 8 below show the correlation of real user monitoring with backend monitoring.

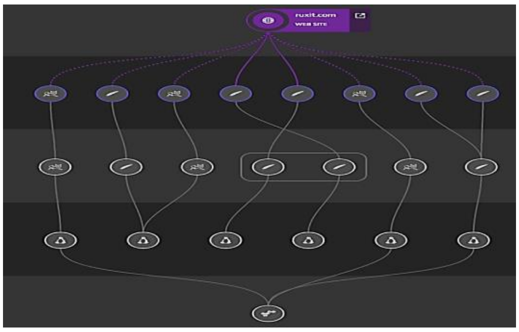

Figure 8 shows correlation between frontend and backend monitoring data

FUTURE TRENDS AND INNOVATION IN REAL USER MONITORING

Real user monitoring is continuously evolving to meet the demands of increasingly complex digital environments. Some areas of potential future research include the following;

A. Integration with Open Telemetry

The use of open telemetry is constantly increasing. Open telemetry is going beyond backend systems. It is evolving into customer-side telemetry and real user monitoring use cases. This could standardize the data collection practices and make full stack traceability and monitoring easy while using opensource tools.

B. AI and Machine Learning integration

Real user monitoring tools are increasingly incorporating AI and Machine Learning algorithms to provide smarter insights and automated optimizations. These algorithms can analyze vast amounts of data in near real time, provide actionable insights, and provide proactive self-healing changes to improve the user experience.

C. Unified monitoring approaches:

Real user monitoring is being made more powerful by integrating it with many other monitoring technologies. For example, synthetic monitoring and application performance management (APM). Bringing all these datapoints into one place and using a powerful AL or ML to analyze the data in real time, increases the power of these observability tools exponentially.

D. Leveraging OpenSource Observability tools

Many open-source tools such as Prometheus and Grafana are gaining popularity among organizations for their cost-effectiveness and flexibility. Although the implementation of these tools is currently more complicated when compared to tools like New Relic or Dynatrace, there is considerable amount of contribution in these tool that address and evolve real user monitoring practices.

E. Predictive user experience analytics

Predictive user experience analytics, is a potential area of research in the field of real user monitoring. AI and machine learning algorithms can be used to analyze historical data and identify trends. This can be used to predict user behavior and identify potential performance issues before they start to impact real users.

F. Multi-channel real user monitoring

Real user monitoring can be evolved to be able to monitor and bring together user interaction data across various platforms and devices like mobile, browser, IoT, augmented reality interfaces, etc. This can provide a unified view of the user's experience across multiple platforms and allow proactive identification of platform specific issues quickly.

Conclusion

Real User Monitoring (RUM) has emerged as one of the most important tools to support and enhance digital transformation, especially in industries like the utility industry. By providing valuable insights into the user interactions with the applications, usage patterns, performance bottlenecks, and errors, real user monitoring greatly enables the improvement of user experience. Integration of real user monitoring with full-stack observability tools allows the utility companies to understand the impact of backend systems on the user experience.

Furthermore, using AI and machine learning greatly enhances the usefulness and power of real user monitoring. AI and machine learning allows utility companies to perform predictive analytics and automated anomaly detection, which can be leveraged as triggers to perform self-healing.

Despite the challenges faced by real user monitoring, such as data privacy concern, complexity of deployment, integration with AI and machine learning, its advancement are paving ways for organizations to deliver reliable, efficient, and user-centric services.

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