Results, Insights and Best-Practices from IIC Testbeds: INFINITE Testbed

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1. INTRODUCTION

This article gathers information from the Industrial Internet Consortium's (IIC) INFINITE Testbed. The information and insights described in the subsequent paragraphs were captured in an interview conducted by Joseph Fontaine, VP of Testbed Programs at IIC, with Donagh Buckley, Senior Director of Dell EMC Research Europe and John O'Sullivan, Researcher at Cork Institute of Technology (CIT).

2. INFINITE TESTBED OVERVIEW

The INternational Future INdustrial Internet TEstbed (INFINITE) was approved by the IIC Steering Committee in January 2015 and was publicly launched in June 2015. INFINITE was designed to develop software-defined infrastructures to drive the growth of Industrial Internet products and services. INFINITE is a state of the art innovation platform and ecosystem of technologies and business expertise covering sensors, gateways, connectivity, cloud, analytics and security. By recognizing that no one organization can do it alone in Industrial IoT (IIoT), INFINITE established strong collaborations between key stakeholders from different domains and sectors working on the common goal of seamless and interoperable infrastructure. From a technology point of view, INFINITE combines the international connectivity solutions from a mobile network provider, the leading Dell 5000 series gateways and Cloud platforms from Dell EMC with the analytics capabilities from Pivotal and leading security solutions from RSA. INFINITE is a strategic partnership between Dell EMC, CIT and other partners.

INFINITE is where the innovation opportunities of the IIoT – new technologies, new applications, new products, new services, new processes – will be conceived, designed, built and validated in a real-world environment to establish their commercial value before coming to market. Through use cases and proof of concepts, INFINITE tackles challenges in IIoT environments that are most important and most likely in the coming years as well as delivering impact across many industry sectors.

3. INFINITE TESTBED PROFILE

INFINITE was purpose-built as a 'horizontal' platform meaning that the combination of the many technologies made available by the INFINITE ecosystem will satisfy almost all of the anticipated technology requirements of future IIoT application domains across all sectors and verticals.

Given the anticipated growth in data across all IIoT sectors, the INFINITE team recognized that advanced infrastructures and technologies are needed to collect, store, and analyze data to meet the IIoT business needs of today and tomorrow. Cloud technologies and virtualization offer powerful new ways to manage and use digital information whilst offering many advantages and benefits for organisations including reduction in IT costs as well as increased scalability and agility for applications, infrastructure and services. The INFINITE team believe in a vision of a converged

infrastructure for IIoT where the INFINITE innovation platform can extend and combine advanced Cloud virtualization or 'software defined' technologies to include connectivity, sensors, gateways and analytics to seamlessly integrate these significant technologies and domains in a way that will deliver business, economic and social impacts.

At the time INFINITE was going through the IIC testbed approval process, almost two years ago, the team proposed an anchor use case, called 'Bluelight.' The aim of Bluelight was to enable smarter and intelligent route planning for emergency ambulance services as they are dispatched to an incident and as they are en-route to the hospital. Providers of emergency ambulance services are critical public safety organizations. They are continually striving to develop and deliver a modern and quality pre-hospital emergency care service that is safe, responsive and fit for purpose within the context of tightening finances and continuously increasing demand on services. Smart Data can enhance and improve the service provided by emergency service vehicles such as ambulances. Consider the scenario where an emergency service vehicle is dispatched to an incident. The response time is critical. What if the real-time GPS data generated by the emergency service vehicle can be combined with other real-time data from diverse sources such as current traffic levels for all routes to the incident, location of roadwork, diversions and road closures? By combining and analyzing these diverse raw datasets in real-time to provide valuable and intelligent route planning and insights in terms of service delivery and optimization, it is expected that response times will improve, leading to better pre-hospital emergency care experiences and outcomes for patients. Other factors including regulatory and data privacy requirements must be taken into account to ensure compliance and security by design.

For the initial phase of the Bluelight use case, the testbed team obtained tracking data from the ambulance service's network to get a baseline understanding of ambulance behavior. The analytics capabilities of INFINITE were leveraged to combine the ambulance tracking data with publicly available open data relating to road traffic volumes, location of roadworks and weather reports throughout the country, for the same time period. The testbed team analyzed the patterns and built prediction models based on the patterns. This analysis enabled the team to gain insights into the factors that impact the ambulance flow and transit times based on the hour of the day, day of the week and week of the month. The testbed team has signed off on a number of successful phases and the results have helped to deliver Service Optimizations and drive improvements in Service Resilience & Service Flexibility.

3.1 Vertical Perspective

Flood Event Advisory Service: One of the vertical use cases within the INFINITE testbed reflects a smart city application: Data analytics is applied to a flood zone to improve an advisory service and quality of life for the public. This smart city use case is in the development phase and it will enable the automation of the collection and aggregation of relevant data from diverse sources, the design and development of analytics functions and flood prediction models as well as enabling an automated flood alert system.

A city in Ireland is built where a river enters the sea and is under risk from two types of flooding: tidal and fluvial (river). The flooding impacts the citizens of the city in many ways:

- Water Damage to Property (Commercial & Residential), Infrastructure and Vehicles
- Commercial Cost: Interruption of Retail, Business and Social Activities
- Public Health & Safety Concerns from the Flooding of Public Areas

The current Flood Prediction and Alert system developed by the local authority has served the citizens well for a long time. It relies on manually monitoring and combining multiple sources of data on a continuous basis to produce predictions and forecasts. The local authority is working with the INFINITE team to explore the possibility of automating the flood prediction process. Automation requires data collection from many sources in real time, including tidal gauges, river level gauges, tidal tables, weather forecasts and combining all of these sources together to develop flood prediction models that will reduce the margin of error in current Flood prediction techniques so that better and more accurate warnings will minimize the impact of flooding in all affected areas. The current early warning system in this city is a subscription based SMS text service. The goal of this use case is to make real time flood predictions and information available on an open data platform and to leverage social media to achieve a more informed public.

The INFINITE team and the local authority expect that the more accurate flood related information and insights will drive a better informed and targeted flood infrastructure prevention investment planning activities. The local authority is driving a smart agenda through a smart gateway initiative. The results and experiences from the Flood event advisory use case will demonstrate how IIoT can play an enabling role in the coordination, escalation and response to Flooding events with other local authority services and government agencies.

First Responder: The “First Responder” use case is a proof of concept (POC) for an IIoT solution that tracks the health and location of first responders. First Responder is designed to improve the safety and effectiveness of first responders when involved in an emergency situation, especially those in harsh environments. According to National Fire Protection Association, more than 60,000 fire fighter injuries in North America alone are reported annually, of which 25 percent are caused by overexertion or strain.

First Responder tracks the location and vital signs of first responders at all times, inside or outside of buildings. A smart, wearable sensor-equipped vest is worn by personnel to monitor useful health metrics including breathing rate, breathing volume and heart rate. A connected boot tracks location and movement. By identifying potential worker health issues immediately and tracking lone workers via these metrics, emergency teams can be healthier, safer and more efficient. All the relevant vest and boot data are collected by an edge gateway device and relayed via the mobile network to the INFINITE testbed. The multiple data streams are collected, aggregated, analyzed and displayed on a portal via a dashboard for access by control teams who may be at the emergency site or in a central control location. The data is analyzed to monitor

worker health and enable a fast response to ensure their safety. Historical analysis of vital signs over multiple responses safeguards continued welfare of safety personnel.

First Responder brings together multiple technologies in a unique way and showcases the need for precise and robust measurement in mission-critical applications. First Responder's platform also allows for future integration of a broader range of sensing technologies to adapt to different mission profiles, including incorporation of precision inertial measurement units for dead-reckoning navigation in GPS-denied environments. Analog Devices' products, can augment the existing first responder platform with a fully integrated and calibrated sensor-suite (gyroscopes, accelerometers, magnetometers and pressure sensor), capable of supporting infrastructure-less navigation in complex extreme environments.

SPARKS: Another use case deployed on INFINITE is called "SPARKS", a European Union-funded H2020 project developing security-driven analytics techniques to detect anomalies or fraudulent behavior within the power grid. Soon, every home and business will have smart meters. Smart meters have an Internet connection that makes them a potential access point for attackers. Cyber-attacks on critical infrastructure can be devastating. In December 2015, a cyber-attack in the Ukraine disrupted the electricity supply to 80,000 people. An attacker could use a smart thermostat to take control of a home-heating system and demand a ransom payment from the home owner. In the SPARKS use case, Dell EMC has developed an analytics-based cyber-attack detection tool that identifies abnormal behavior in the electrical grid, which could indicate an attack. A key component to protection of critical infrastructure is cyber-attack detection. Through machine-learning algorithms, it will be possible to identify abnormal behavior in the grid and, then, use this information to alert other parts of the security system to limit the impact of attacks.

Some data sensitivity and privacy issues restrict the sharing of all results from the use cases described above. However, where there are opportunities for open data platforms, such as the Flood Event Advisory Service use case, the INFINITE testbed team plan to promote the results within the IIC community.

4. IIC ECOSYSTEM

Partnerships have emerged within the INFINITE Testbed that include relationships between IIC members as well as non-members. The IIC ecosystem facilitated some partnerships while others were serendipitous.

Analog Devices and Dell EMC were exploring a formal relationship when they realized they were both IIC members. This common denominator gave them each good reason to evolve the relationship. What began as speculative conversations deepened as their IIC memberships provided a common discussion topic and led more quickly to the discovery of similar goals. As conversations turned to testbeds, the relationship sped up. With the INFINITE Testbed only 6 months old (July 2015), Dell EMC's testbed activity and both parties' involvement with the IIC helped to crystalize the problems they sought to address and work together to find the solutions.

As another example, Asavie and Dell EMC, were discussing participation in the INFINITE Testbed when the activities and importance of the IIC were highlighted. Asavie joined the INFINITE Testbed in early 2016 and the Asavie PassBridge™ IoT Connectivity Platform delivers the underlying connectivity platform for the INFINITE testbed.

"Asavie is fulfilling an important role in the industrial IoT community through their involvement with INFINITE. As the need for more dynamic systems continues to grow, organizations are utilizing mobile networks to connect to virtual systems. Asavie PassBridge technology enables companies prove the viability of doing all this in a secure and scalable manner on the INFINITE testbed." - Donagh Buckley

As the discussion developed, Asavie recognized the value of IIC membership and joined the IIC shortly thereafter.

As the INFINITE Testbed grows, there are plans underway to expand the roles of existing partners, as well as add new partners. CIT has established a campus company to manage the day-to-day operations of the INFINTE testbed and to grow and develop the IIoT ecosystem of technology, partners and expertise. Any organization, regardless of size, sector or location can join the INFINITE testbed. A Membership model has been developed that offers members many benefits including access to the testbed resources, technological expertise and networking opportunities. This enables the offering of a truly open platform that will enable the growth of the IIoT ecosystem.

5. OUTCOMES

From the many use cases, in their varying levels of maturity, the INFINITE Testbed team has learned specific lessons, discovered and documented best practices and experienced outcomes that will help improve the lives of those living within the boundaries of the deployments and be the foundation for expanding the innovations to reach larger populations.

The INFINITE team developed a use case engagement process that takes into account the multi-vendor and multi-partner composition of the INFINITE ecosystem. This unified process is an end-to-end integration of different partner and technological processes that combine to support all activities covering initial use case engagement with INFINITE customers, requirements specification, design, deployment, results and use case sign-off.

Bluelight: The results of the early phases of this use case are not publicly available but important factors were discovered that affect ambulance speed and transit times. The insights from this use case will drive improvements in service resilience and service flexibility for ambulance service.

Flood Event Advisory Service: This use case is not fully deployed but the testbed team anticipate impacts such as greater efficiencies through the automation of manual processes and improved accuracy of Flood Prediction events leading to better informed public.

First Responders: The outcomes of the early phase of First Responder has delivered an end-to-end, integrated solution covering connectivity, cloud and enterprise analytics. The testbed team has:

- Validated primary requirements of reliability and robustness for mission critical applications.
- Identified areas for further development
- Built a better understanding of First Responder requirements

SPARKS: This use case required a solution that securely collects and stores data from Internet Protocol (IP) enabled meters. At the enterprise analytics end, the testbed team has developed machine learning algorithms for anomaly detection and these machine learning algorithms can be applied to other areas such as monitoring Operational Technology (OT) elements.

6. OTHER FINDINGS AND SURPRISES

The progress of the INFINITE testbed has been influenced by the maturity of the IIoT conversations among business executives. The testbed team have found that everyone has heard of [industrial] IoT and a lot of organizations are still developing an understanding how it will affect them. Industrial IoT is complex and will affect many functions within organization, not just the IT and technology functions. The INFINITE team have found that the technology complexities and risks are a deterrent for many organizations. The vision for INFINITE is to simplify the technology so that organizations can focus on business innovation.

One of the unexpected, big surprises that Donagh and his team found was that the initial conversations have been exclusively technical, but more and more there is a gradual move toward discussing the business benefits and organizational transformation required for IIoT. The identification of these business benefits will help the transformation of the conversations necessary for IIoT adoption.

Donagh also explained that a lot of interest can be categorized as ‘early stage’ and that there are many iterations of discussions and meetings before a use case is defined and deployed on INFINITE. Customers are excited and see the benefits of IIoT. INFINITE simplifies the technology complexity and makes available an ecosystem of key domain specialist skills so that customers can focus on innovation. The INFINITE team are building up a knowledge base of common questions and challenges that organizations face across all sectors.

7. PLANNING

When the INFINITE testbed was proposed, the many use cases described above were not yet imagined. With the evolution of the INFINITE partnerships and ecosystem and through the promotion of INFINITE at various trade shows and events, a lot of interest was generated across many sectors resulting in many discussions and meetings about IIoT challenges, new ideas, proposals, use cases and proof of concepts

Success for INFINITE is not about a single organization but about the strength in depth and technical capabilities of its partners and ecosystem. The INFINITE proposition enables the testbed team to leverage Dell EMC's strong proposition in edge gateways as well as their large ecosystem of partners that OEM on their gateway solutions. Dell EMC provide the leading cloud and storage platforms for INFINITE. For Application Developer frameworks, INFINITE integrates Pivotal Cloud Foundry (PCF) which enables an open Platform-as-a-Service that supports a wide variety of programming languages, developer frameworks and application services. Pivotal is a subsidiary of Dell. At the Analytics layer, INFINITE has deployed the Pivotal Big Data Suite (BDS) services for PCF which include Pivotal HAWQ, Pivotal HD, Redis, RabbitMQ and SpringXD. Security is a key requirement for IIoT and the INFINITE testbed offers industry leading security solutions from RSA, a Dell subsidiary. The INFINITE testbed offers local and global connectivity through a dedicated mobile network Machine to Machine (M2M) Access Point Name (APN). Asavie aggregates connectivity from sensors, gateways and devices across multiple diverse networks into one single network, managing and securing the data as it flows to and from INFINITE. The INFINITE team are also developing relationships with a specialist sensor companies.

8. IIC INTERACTIONS

INIFINITE was approved (January 2015) by the Industrial Internet Consortium Steering Committee before the Industrial Internet Reference Architecture (IIRA) and the Industrial Internet Security Framework (IISF) were released. The INFINITE team plan to revisit the testbed alignment with the IIRA and the IISF to ensure compliance. They will also feedback their evidence-based experiences and many lessons learned from the use case deployments to the Technology and Security Working Groups who are charged with refining and updating the IIRA and IISF documentation for the IIC.

There is recognized value in being an approved IIC testbed, especially with the growing recognition of the importance of the IIRA and the IISF within IIoT. For some testbeds such as INFINITE which emerged prior to the IIRA and IISF publications, the future evaluations based upon these resources will provide the opportunity to showcase the testbed's alignment with the architectural considerations of the IIRA and incorporate the guidance on IIoT security developed in the IISF. The testbed team looks forward to showcasing its compliance with the IIRA and IISF especially as these technical documents have gained recognition.

9. CONCLUSION

INFINITE is an example of how diverse technologies such as sensors, connectivity, cloud, analytics and security can create new business models and value chains in the Industrial Internet of Things. In order to be effective, INFINITE requires strong partnerships between leading technology providers and business expertise from different domains and sectors to work on the common goal of seamless and interoperable Infrastructure. The innovations developing and in action in the INFINITE Testbed and its many use cases are delivering impacts including quality

improvements of mission critical systems for emergency services, first responder safety, flood warning systems and other applications. The openness of the testbed and the partnering within and outside of the IIC that has led to these successes are a testament to Dell EMC's and its partners' broad vision of the technology solutions covering Edge, Cloud and Analytics that will address the challenges within mission critical environments.

Visit the INFINITE Testbed webpage for future progress updates.

10. TESTBED PARTICIPANTS

- Dell EMC/RSA/Pivotal
- Cork Institute of Technology
- Asavie
- Analog Devices

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