



Enabling a New Era of Smart Enterprises

Aseem Parikh

Vice President, Solutions & Partnerships

ONF

Executive Summary

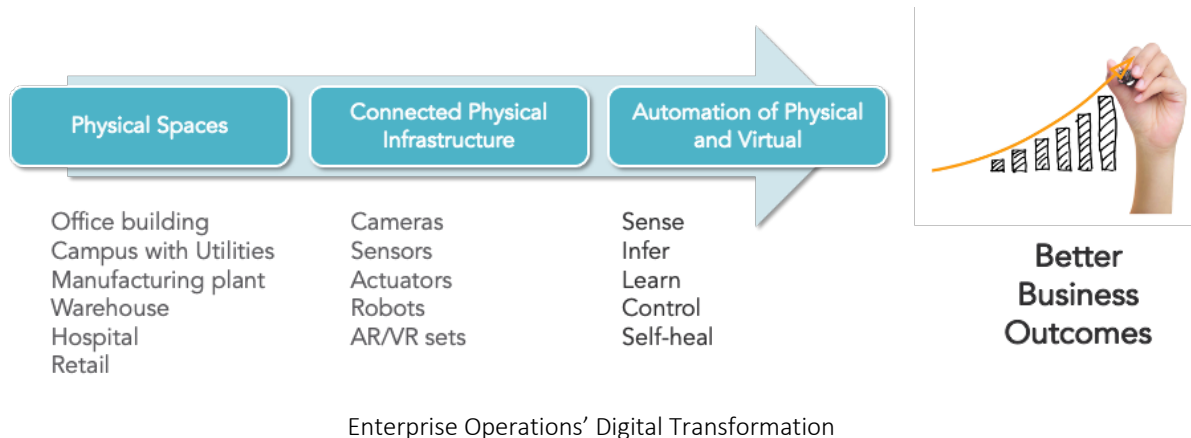
Reliable connectivity, secure data management and pervasive process automation have played a central role in the evolution of the enterprise towards a smart digital enterprise. With the increasing use of robots, cameras and IIoT devices and sensors, robust, low-latency and secure wireless connectivity for mission critical applications is required by enterprises to enable new operational technology solutions. Current WiFi networks do not have the necessary predictability, reliability, low-latency and data security. The existing closed and bespoke private cellular solutions are too expensive and complex to deploy, and hence, still out of reach of most enterprises. ONF's innovative Aether™ platform is democratizing private cellular connectivity and the 5G connected edge cloud for enterprises. Aether is serving as a catalyst for accelerating smart enterprise digital transformation with open source, software-defined cellular connectivity and tightly integrated cloud native edge compute on COTS hardware.

Table of Contents

1. INTRODUCTION.....	2
2. MARKET	4
3. NECESSITY: FROM BESPOKE+CLOSED TO GENERAL PURPOSE+OPEN SOURCE	4
4. WHAT IS AETHER?	5
5. TARGET USE CASES AND DEPLOYMENT SCENARIO	8
6. KEY BENEFITS TO SMART ENTERPRISE	10
7. A QUICK LOOK UNDER THE COVER	10
8. AETHER PILOT NETWORK AND ECOSYSTEM.....	11
9. CONCLUSION.....	12

1. Introduction

For several years, digital transformation of enterprise operations, aided by industrial IoT, big data analytics, AI/ML, and resulting automation and closed-loop control, has been on the top of the priority-list for most enterprise CIOs. CEOs and CIOs wish to drive favorable business outcomes by getting real-time visibility and control of their physical facilities, raw goods and infrastructure, work-in-progress and operational processes, with an eye to increase competitiveness, productivity and return on investment.

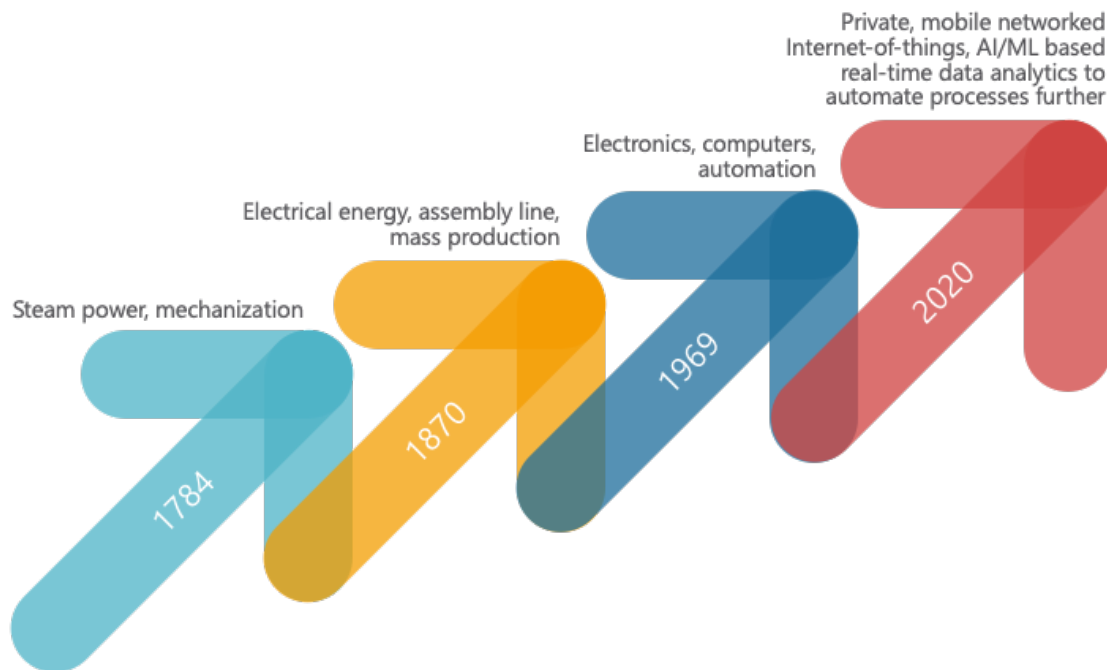


To achieve these business goals, some hard problems need to be solved:

- Secure, high throughput and reliable connectivity is needed between machines/sensors/things (many of which are or will be mobile or untethered) and control processes;
- Ability to implement near real-time low-latency control loops; and
- Balancing enterprise data sovereignty and compliance while leveraging the public cloud.

Today's readily available solutions - enterprise WiFi or MNO-provided cellular connectivity, and public/private cloud-based compute are unable to adequately solve these issues. Thus, until now, the desired transformation has been illusive to most. Only the largest and well-heeled enterprises could overcome the technical and business challenges to undertake and benefit from this deep transformation. The few businesses who have successfully peaked this mountain - the likes of Amazon, Bosch Rexford, Harley Davidson, Stanford Hospital and Tesla Motors - have reported incredible gains in productivity, efficiency, safety and security.

Luckily for the vast majority of enterprises, the advent of 5G over CBRS or similar free to use spectrum, edge cloud and mature open source SDN platforms is the trifecta that can and will unleash solutions that will deliver the desired benefits promised by the so-called Industry 4.0 revolution.



Industry 4.0 digital transformation will be accelerated by Private 5G/CBRS, Edge Cloud and SDN, allowing enterprises to smartly use data to drive better business outcomes

ONF is bringing its expertise in mobile networks, edge disaggregation, SDN and cloud native technologies to build an open source platform to catalyze such enterprise connectivity solutions. We call this platform Aether™. This whitepaper describes Aether's motivation, capabilities, target use cases and the key value proposition.

2. Market

This exciting phase of smart enterprise transformation represents the next big computing and communication build out. **Gartner**¹ reports that within four years, half or more of enterprise applications in production will be IoT ready; this in turn will require robust and reliable connectivity to the enterprise apps. **IDC's** recent **FutureScape** report also notes that “70% of IoT deployments by 2023 will include edge-based decision making to support organizations' operational and strategic agendas” and that “70% of enterprises will run varying levels of data processing at the IoT edge”².

With every enterprise as a potential user and many tech companies positioned to participate in this market, a recent report by **KPMG** estimates the private 5G edge cloud market to be north of \$500 billion³. 650 Group projects a \$17.6 billion TAM within five years specifically for private cellular connected edge infrastructure and services.

3. Necessity: From Bespoke+Closed to General Purpose+Open Source

A closer look at companies like Amazon and Tesla, who are well down the path of this transformation, highlights the big chasm that needs to be crossed by others. These forward-looking companies have the means and/or the expertise in-house to procure and/or build bespoke operations/process automation platforms and solutions, strategically investing millions of dollars and many man-years of engineering. Also, in order to reap outsized benefits over several years, they have to continue to invest handsomely to keep their applications/platforms abreast with advances in underlying technologies. Given what it takes, it is no surprise that only a few embark on this arduous path, however lucrative.

¹ Gartner, “Forecast Analysis: Enterprise IoT Platforms, Worldwide.” Report, 20 April 2020

² IDC FutureScape, “Worldwide IoT 2020 Predictions.” Report, October 2019

³ KPMG, “The 5G Edge Computing Value Opportunity.” Report, June 2020



A general-purpose open-source platform is required to unleash Industry 4.0

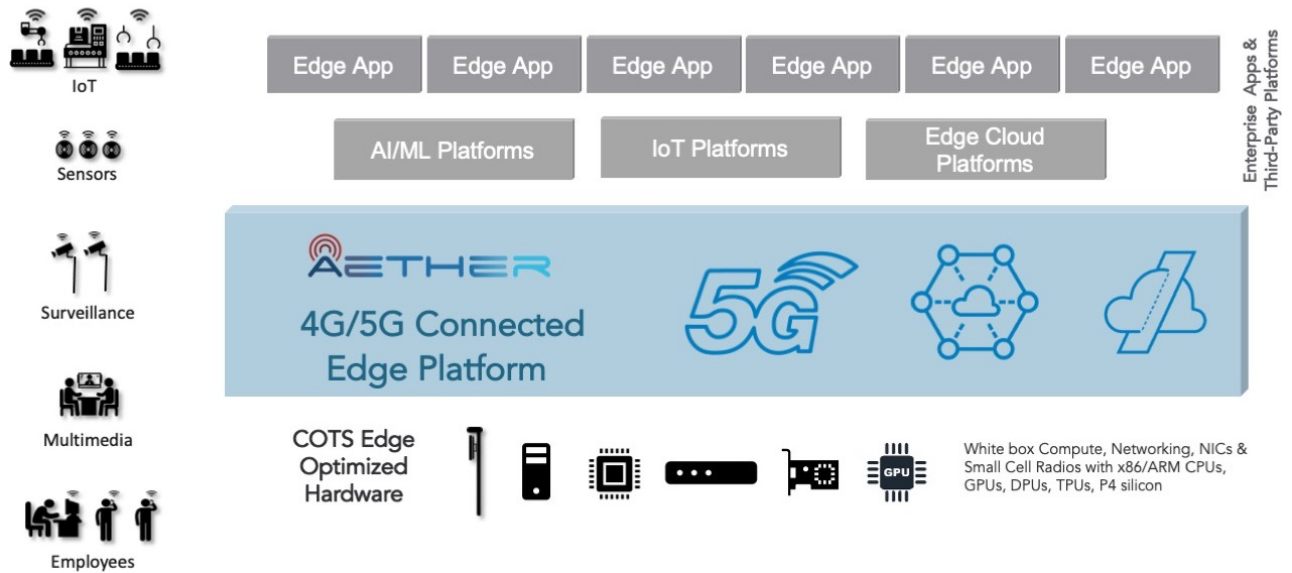
History has shown repeatedly that when open and easily customizable platforms are developed to enable solutions that compete with closed proprietary solutions, the solutions based on open source platforms are more readily adopted and the market tends to expand multifold. To cite a few examples of this market behavior, remember Sun’s Solaris versus Linux, in the server OS segment and Nokia’s Symbian versus Android for the smartphone OS vertical. Clearly Linux and Android accelerated innovation, democratized the supply chain and grew the target market by several orders of magnitude.

ONF and its partners’ approach to developing Aether as a common open source platform for private 5G connected edge builds on this playbook. ONF wishes to channel the “Android effect” onto the private enterprise connectivity solution and bring the industry together to support a common 5G connected edge platform.

4. What is Aether?

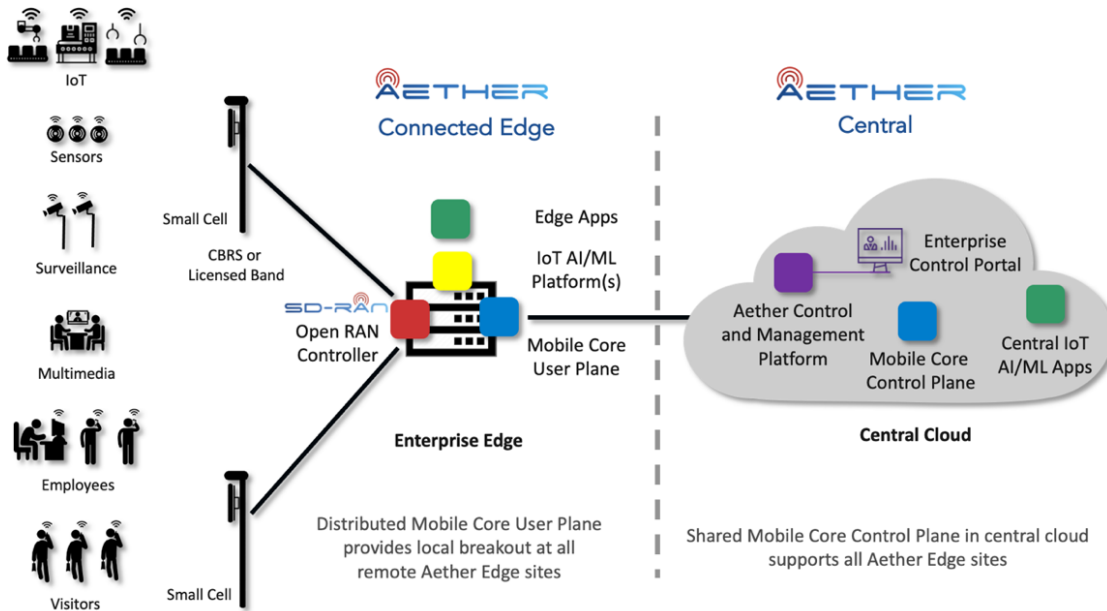
ONF’s Aether is an open source enterprise software platform for leveraging private cellular connectivity and multi-access edge compute (MEC) for mission critical applications and operational use cases. Aether is the first and only fully open source platform for private, secure, software-defined enterprise LTE/5G connected cloud native edge, designed to be cost-effectively delivered as a service.

Enterprise Devices



Aether 4G/5G Connected Edge platform supports diversity of OT Applications to connect to diverse set of IIoT devices over private cellular network

Aether uses and builds upon production-tested open source components from ONF like ONOS®, Trellis™ and CORD®, and other general purpose mainstream projects (e.g. Kubernetes, Rancher, etc.). Aether runs on open-spec commodity compute and networking hardware and connects with 3GPP compliant small cells for cellular access. Architecturally, Aether leverages state-of-the-art cloud, software-defined and micro-services principles. Aether integrates with and offers onboarding and lifecycle management of commercial operational platforms for video stream analytics, IoT and AI/ML, as well as custom enterprise edge applications.



Physical deployment of the distributed Aether platform

The Aether platform is typically deployed at the enterprise site(s), with control and management performed from a central cloud. The enterprise-deployed Aether software stack - called "Aether Connected Edge" (ACE), hosts the commercial third party or in-house edge apps requiring low-latency and highly available connectivity to devices and enterprise systems. Additionally, it hosts the disaggregated O-RAN compliant cellular connectivity software stack and terminates the mobile user plane for enabling local breakout leveraging an SDN-managed switching fabric.

Designed to be delivered as a cloud managed service, Aether offers a harmonious substrate consisting of three enterprise services, enabling a) private cellular connectivity, b) connected edge cloud, and c) fine-grained traffic visibility and control service. Rich northbound and southbound APIs allow the platform to host the enterprise operational platforms and applications, connect them to data sources and collect rich telemetry from the connected endpoints along with the data they exchange.



Functional view of Aether cloud-managed open-source platform

Key attributes of the underlying services that make Aether very competitive are listed below:

Private 4G/5G Connectivity Service:

- Best of the both worlds – WiFi’s simplicity and economics, and O-RAN/CBRS-based 5G wireless network’s performance and security;
- Predictive end-to-end performance between device, radio access network and enterprise application, with configurable quality of service (throughput, delay and jitter) per use case;
- Wire-speed local breakout implemented by intelligent switching hardware; and
- Higher reliability and higher wireless coverage than WiFi.

Connected Edge Cloud Service:

- Leverages Aether’s cellular connectivity service to enable seamless integration to cloud-native edge compute;
- Scalable infrastructure from small to very large enterprises;
- Supports low latency connectivity for mission critical use cases;
- Compute clusters interconnected with an intelligent (SDN) switching fabric capable of up to 100 Gbps port-to-port throughput;
- Runs on well-qualified COTS hardware with support for x86, GPUs and smart-NICs; and
- Easy onboarding and life-cycle management of edge workloads by user/ISV.

End-to-End Slicing and Fine-grained Traffic Visibility Service:

- Partitions the enterprise cellular network into multiple slices, each with a specific quality of service profile;
- Provides for the enterprise dev-ops to assign applications and devices to assure the required QoS – a combination of throughput, latency and jitter;
- Hardware assisted data traffic and resource utilization telemetry; and
- Programmable micro-collection for troubleshooting or security audit.

Over the next 12 months, the Aether platform’s service portfolio will be further enhanced by new innovations ONF and its research partners are working on, to include:

- **Connectivity Verification Service** – offering ability to observe and guarantee that the traffic between the enterprise’s Aether-visible endpoints is secure and adhering the company’s network policies.
- **Connectivity with Closed-loop Control Service** – for optimization for network resources and addressing in real-time network anomalies or nefarious attacks.

5. Target Use Cases and Deployment Scenario

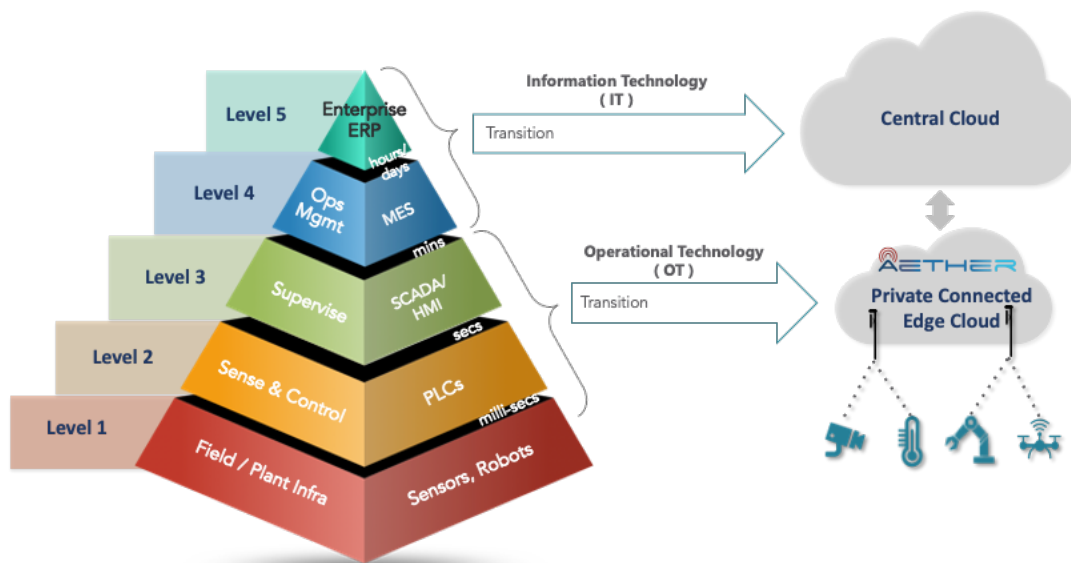
Aether is an essential connected edge cloud platform for all mission critical enterprise applications that require low-latency connectivity to infrastructure, with much higher reliability, privacy and security than offered by either WiFi or national mobile operators. Primary target use cases where Aether is expected to shine are shown below.



Target Market Verticals for the Aether Platform

A popular way to reason about industrial digital transformation is the Automation Pyramid shown in the figure below. The communication and compute required for levels 1, 2 and 3 have much stricter latency constraints (sub-second). These mission critical technology components are generally termed as operational technology (OT), as opposed to the IT components like manufacturing execution system (MES) and enterprise resource planning (ERP) systems.

The Aether platform is ideally suited to host the virtualized OT applications and platforms and offers low latency communication with QoS for these to communicate with the field/plan infrastructure.



ONF's Aether hosts and connects next-gen OT components of Industry 4.0 Automation Pyramid

6. Key Benefits to Smart Enterprise

Aether's many technical innovations and managed service delivery model offer several unique benefits to the enterprise that adopts this platform. These include:

- **Assured Connectivity for Mission Critical workloads:** Aether offers predictable and high bandwidth low latency connectivity with quality of service guarantees for OT applications, enabled by network slicing. The edge compute workloads are highly available as a result of the self-healing orchestration of micro-services via Kubernetes.
- **Data Sovereignty & Control:** Some data can't be in the cloud and needs to stay local, either because of proximity to the source of data or the cost of shuttling the data between private infrastructure and the cloud. Another reason is sometimes due to the sensitivity of the data or regulations. Aether enables local breakout of such mission critical data traffic. This allows enterprises to retain top-down programmable control of their systems and data, in turn, allowing enterprises to control their own destiny and avoid becoming locked into any single hyper-scaler's ecosystem.
- **Security:** Aether complies with 5G/3GPP security standards, and hence offers end device security equivalent to a national mobile network provider. The deep traffic visibility and programmable access control offers extra layers of protection.
- **Compelling Economics:** ONF's Aether is available as open source software, and it runs on COTS hardware and small cells from a selection of certified ODM vendors. Aether leverages free to use cellular spectrum such as the CBRS band in the US and dedicated licensed bands for enterprise use in Germany, and soon also in the UK, Sweden, Hong Kong and Australia, with more countries to follow. This makes Aether less expensive than managed WiFi per sq. ft of coverage, but just as easily consumable.
- **Ease of WiFi:** Aether tames the complexity of the LTE/5G standards to enable an easy-to-consume connectivity service that is as adaptable as WiFi, but with all the architectural benefits and predictable performance of a 3GPP-compliant solution.
- **Scalable Hybrid Cloud Support:** The cloud native Aether edges are designed to work with enterprise apps running on private or public central clouds. The Aether edge compute infrastructure can be elastically scaled from very small (a couple of servers) to very large (several racks) connected by a spine-leaf SDN fabric.

7. A Quick Look Under the Cover

At ONF, building on our well-established, operator-approved and deployed platforms, we have developed Aether, a cloud-enabled private mobile network system for enterprises. Aether

flexibly leverages all available spectrum bands, including both operators' licensed bands and the CBRS band. Aether creates an Enterprise-5G/LTE-Edge-Cloud-as-a-Service, enabling simple and seamless deployment of mobile connectivity integrated with enterprise edge cloud capabilities, all centrally orchestrated from the public cloud. Aether makes it possible for enterprises to deploy mobility and edge services across a multi-site footprint as an elastic and scalable cloud service.

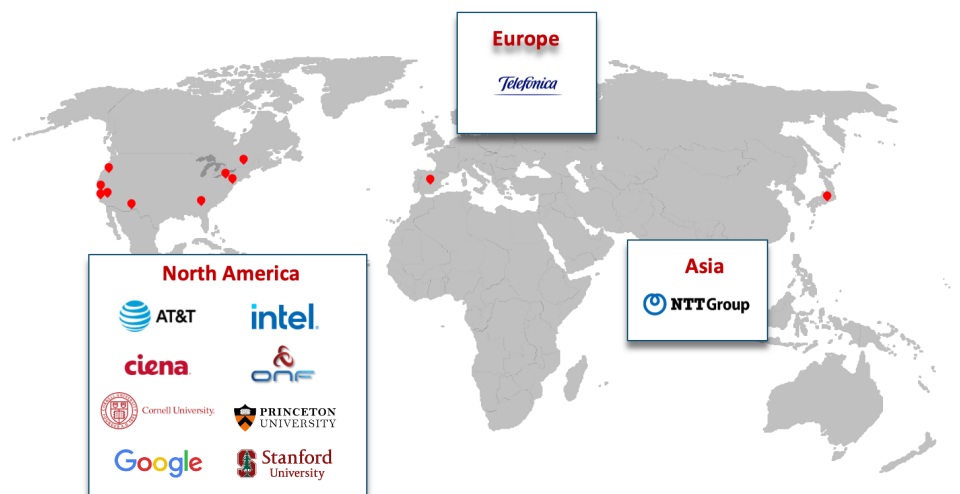
The Aether platform and its services are constituted by bringing several pioneering innovations together and refactoring open source components from ONF and other communities for the enterprise connected edge use. To illustrate this, a few examples are listed below:

- Private 4G/5G service over CBRS, with open RAN and disaggregated packet core;
- Richly configurable end-to-end network slicing;
- Programmable wire-speed mobile user plane function (UPF) for local breakout;
- SDN programmable forwarding substrate leveraging P4-capable hardware;
- Multi-cloud/Hybrid cloud support with CI/CD and DevOps enablement; and
- Centralized management and operational tooling.

For further details on the platform architecture, building-block components, and service capabilities read the in-depth [Aether Technical Brief](#).

8. Aether Pilot Network and Ecosystem

Thanks to the enthusiastic support from ONF partner companies and a \$30M grant from DARPA, ONF operates a single centrally managed Aether pilot network interconnecting a number of edge locations.



ONF Pilot Network Deployments Today

This network allows ONF to harden Aether while learning first-hand the challenges of managed service delivery and operationalization, thus enriching the Aether platform with these real-world lessons.

A critical mass of vendor ecosystem is demonstrating interest in Aether, including:

Small-cell Vendors: **Accelleran, BaiCells, Sercomm**

Silicon Vendors: **Barefoot/Intel, Broadcom, Mellanox/Nvidia**

COTS Networking Hardware: **Edgecore Networks**

Edge Apps, AI/ML Stack: **Google Cloud**

Edge Cloud: **Microsoft Azure**

Enterprise Apps: **Aryaka, Ciena, GS Lab**

9. Conclusion

Designing, deploying, and maintaining mobile networks have traditionally been expensive and complex, minimizing the wide-spread deployment of private mobile networks. The technology pillars of disaggregation, virtualization, SDN'ization, and cloudification that are fueling the transformation towards 5G provide the foundation for addressing these issues. One additional enabler for private enterprise networks is the advent of new types of available spectrum for such networks, namely, the CBRS band in the US and dedicated licensed bands for enterprise use in Germany, and soon also in the UK, Sweden, Hong Kong and Australia, with more countries to follow.

Aether, the industry's first open source private 5G connected edge platform, has been built on these technology pillars and offers ease and economic advantages of managed WiFi, while serving the more stringent requirements for enterprise OT applications. In doing so, Aether will serve as a catalyst to accelerate the smart enterprise transformation and precipitate the aforementioned "Android effect" for the private 5G connected edge.