Technology Whitepaper

Edge Branch

An EdgeNet based 5G Edge Service

List of Figures & Tables

Abbreviations and Acronyms

The table below provides a glossary of acronyms and terms used in this document

Term	Definition
API	Application Programming Interface
AVSW	Alef Virtual Switch
CBRS	Citizens Broadband Radio Spectrum
CDR	Call Data Records
CPU	Central Processing Unit
CSP	Communication Service Provider
CR	Change Request
DaaS	Desktop as a Service
DNS	Domain Name Service
EaaS	Edge as a Service
ESW	Enterprise Switch
IDC	International Data Corp.
IaaS	Infrastructure as a Service
IoT	Internet of Things
IPDR	Internet Protocol Data Records
KPI	Key Performance Indicator
KVM	Kernel-based Virtual Machine
NAT	Network Address Translation
NFV	Network Function Virtualization
OPR	Operator Proxy Radiolet
QoE	Quality of Experience
RAM	Random Access Memory
SASE	Secure Access Service Edge
SDN	Software-Defined Networking
SD-ME	Software Defined Mobile Edge
SDMN	Software Defined Mobile Networking layer, part of Alef's SD-ME architecture
SD-WAN	Software Defined Wide Area Networking
SLA	Service Level Assurance
UHB	Ultra-High Bandwidth
UI	User Interface
ULL	Ultra-Low Latency
VDI	Virtual Desktop Interface
VM	Virtual Machine
WAN	Wide Access Network

1. Introduction

Today's branch office data center is a critical piece of IT infrastructure for any distributed Enterprise. Functionally, this includes: Wi-Fi access equipment, networking gear, WAN optimization software, security engines, enterprise specific apps, etc., consolidated across on-premises data centers. In particular, the branch office network provides reliable, secure, easy to deploy, high-quality communications across branch offices. While there has been a steady migration of applications to the cloud, the branch data center continues to include legacy and mission critical application servers increasingly being installed on commercial off-the-shelf (COTS) hardware. Despite cloud adoption, the complexity of such branch office networks has only increased and managing silos of applications and individual branch office networks requires deep domain expertise.

Edge Branch - a 5G Edge service that addresses the need for a dynamic, on-demand, agile and extensible platform and infrastructure solution based on EdgeNet

Software Defined (SD) technologies, such as SDN, SD-WAN and NFV have come to the rescue in branch networks, leading to reduced complexity and a corresponding reduction in operational costs. For instance, SD-WAN solutions have enabled the consolidation of various WAN optimization functions with a centralized management plane that is automated. Similarly, Security Engines and Applications have also undergone consolidation through virtualization and containerization with console based centralized management. In addition, SD-Branch solutions in the market attempt to further optimize branch office infrastructure with a view towards consolidation of single function devices, cost reduction and ease of management. More recently, as Digital Transformation in the Enterprise gains adoption, 5G Edge solutions involving low latency, high bandwidth, AI/ML, Autonomous Systems, I-IoT, IoMT, etc., with portability, mobility, and roaming are redefining enterprise IT architectures.

In summary, today's enterprise branch office architecture is optimized for fixed-line, private enterprise, local and wide-area networking, and existing applications on-premises and the cloud. As end users and devices embrace portability/mobility and roaming in the midst of a pandemic, get ready for a post pandemic world, and enterprises adopt the next generation of applications, such optimizations don't suffice. New disruptive architectural approaches are critical.

Mechanisms to provide flexible and remote access to Enterprise infrastructure and applications have been around for a few decades with incremental but continuous improvements. Given the pandemic, remote access is not just "good to have" but a "must have" capability. Moreover, Digital is practically the only way to conduct business! While the use of Cloud Computing and Cloud Native technologies has given IT staff immediate tools to migrate certain workloads, these patchwork solutions do not address the tectonic shift underway. **What is needed** is not just flexibility in access, but agility in branch office infrastructure and workload management!

This white paper focuses on Edge Branch – a 5G Edge Service that addresses the above need for a dynamic, on-demand, agile, and extensible platform and infrastructure solution based on EdgeNet[1]. EdgeNet's hyper distributed Internet Edge architecture is inherently suited to creating a shared and secure Branch office at the Edge for the remote office worker that mimics and creates a typical Branch office location on demand close to the consumption endpoint. This improves application performance, addresses security threats while significantly improving productivity.

[1]White Paper - EdgeNet and "The 5G Edge API"

2. Target Audience

The target audience for this paper includes Enterprise IT Managers, CIOs, CTOs and enterprise/freelance developers. We begin by listing key concerns and additional considerations to ensure Edge Branch addresses these concerns and considerations.

Key Concerns
- **Ease of Operations**
- **Lowering IT Costs**
- **Security**

2.1 Key concerns

IT Managers - are concerned with ease of operations, lowering IT costs (or at a minimum remaining inside their budgets), and properly securing their network and endpoints. CIOs/CTOs - are focused on policy control, security threats, managing their overall budgets, and getting the most out of their investments. Moreover, they are concerned with strategic technology investments, digital transformation, optimizing technology resources and building a strong developer community, while simultaneously meeting time to market requirements given the competitive nature of business environments. Developers – across the board, software professionals (both application developers and network programmers) are looking for easy to use APIs, SDKs, connectors, along with quick start guides to rapidly create and launch the next generation of digital services.

2.2 Additional Considerations

Accelerating current digital transformation activities – do Enterprises have any cloud assets and how do they communicate with them? This will help determine the value they can get out of the Edge Branch solution.

Understanding Enterprise remote work Security concerns - what are Enterprises using for securing their remote workers and are they facing any problems with their security systems? This will help identify areas of security threats.

The role of mobility - does the Enterprise have a flexible anytime/anywhere/on-the-go IT approach? If so, how does this network integrate with their overall communications? Application performance - what applications are remote workers currently using and do they face performance issues?

3. Remote Work Problem Statement

The problem statement around increasing remote work from home is captured below:

Key Concerns
- **Ease of Operations**
- **Lowering IT Costs**
- **Security**

3.1 Key Issues Surrounding Remote Work

- There is a virtual explosion in the number of "home/mobile branch offices" -thousands of home/mobile branch offices (proportional to the number of employees).
- This has led to a massive increase in the number of "virtual branch offices and connections" to secure and manage.
- Security is of paramount importance. The FBI has seen a 400% increase in cybersecurity attacks since the Covid-19 pandemic began[2]. Moreover, security must be consistent and easy to implement and use. VPNs and centralized security inspection engines try to enforce security by bringing the data into secure zones versus bringing the security inspection engines to the application or session. They are difficult to manage, costly to operate and result in added latencies in the network.
- Home/Mobile Branch - The last mile is an "unreliable" broadband connection, without redundancy and with no control on latency, which is potentially high. This problem is partially being addressed through additional 4G/5G dedicated home branch "MiFi" connections. The advantages of MiFi devices are mobility and the ability to create mobile branch environments dynamically and securely. However, MiFi connections are best effort and coverage constrained.
- Cloud Applications accessed from home/mobile branches cannot rely on potential cloud interconnection or cross connects that are available from branch offices (or data center cross connects) to speed them up.
- There is a huge increase in the usage of virtual desktop interfaces. The virtual desktop infrastructure market is poised to grow by $3,886 million during 2020-2024, at a CAGR of 10% during the forecast period[3]. Along with this growth comes three common problems with VDI – poor user experience, solution complexity and high costs[4]. These problems need to be addressed.
- There is a significant increase in the usage of video conferencing applications by home users (Example: virtual education, home Internet and entertainment) making the shared last mile even more unreliable. According to Gartner, by 2024 remote work and changing workforce demographics will impact enterprise meetings so that only 25% will take place in person, down from 60%today[5].
- The net result is Enterprise applications are best effort, without high availability and they cannot take advantage of existing branch office SD-WAN solutions and services.
- Current SD-WAN technology is not built for low latency; only for transport and wide-area network cost optimization. While Enterprises are using SD-WAN technology in ever greater numbers, the fundamental promise of SD-WAN lies in optimizing the cost of bandwidth that is used to connect branch office locations to each other and to the cloud, by using lower cost broadband links as long as SLAs are met. SD-WAN does not address the issue of latency or application performance, which is perhaps more relevant in the context of Enterprises deploying low latency 5G Edge applications to accelerate their Digital Transformation.

[2] Work from home cyber security risks
[3] Global Virtual Desktop Infrastructure Market 2020-2024, published May 8th 2020
[4] VDI Challenges and How to Solve Them by Ruben Sprujit, Nutanix.
[5] Gartner Magic Quadrant for Meeting Solutions, published October 12th 2020

These problems are partially illustrated in the diagram below, showing a home user located on the perimeter having to connect to his/her branch office, their Enterprise Data Center, as well as the Cloud for certain applications. While the branch offices themselves can communicate over SD-WAN optimized links to the Data Center or to the Cloud, the home user working remotely cannot take advantage of this optimized network and has to set up sub-optimal individual links to each of these locations.

Key Concerns
- **Ease of Operations**
- **Lowering IT Costs**
- **Security**

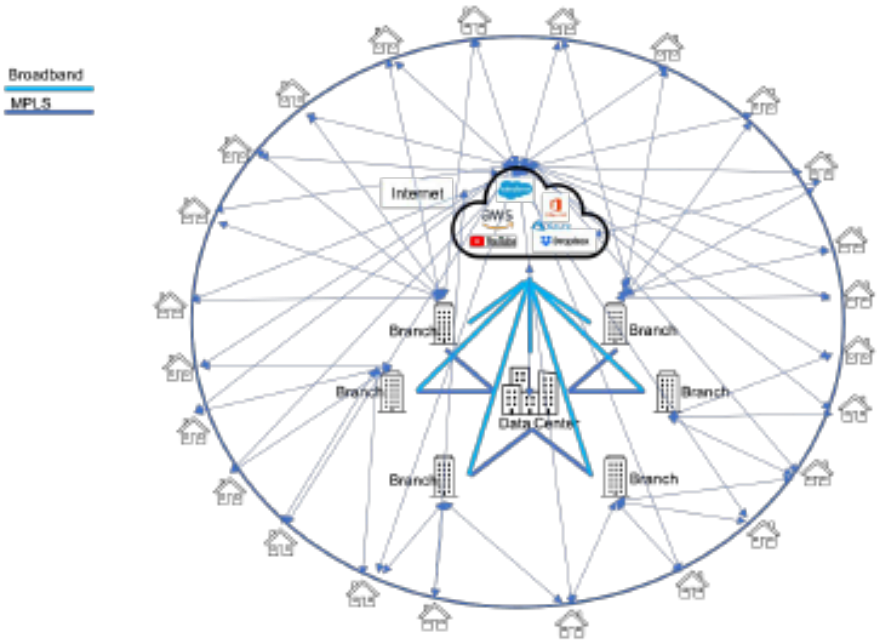

Figure 1: Current Work-From-Home Environment before Edge Branch

[2] Work from home cyber security risks
[3] Global Virtual Desktop Infrastructure Market 2020-2024, published May 8th 2020
[4] VDI Challenges and How to Solve Them by Ruben Sprujit, Nutanix.
[5] Gartner Magic Quadrant for Meeting Solutions, published October 12th 2020

4. EdgeNet based Edge Branch Architecture

This section describes how EdgeNet based Edge Branch Architecture solves the burning problems of Remote Work captured in the previous section. We start by describing the EdgeNet Reference Architecture as applicable to Edge Branch and illustrated in Figure 2 , and has the following principal characteristics:

- Shared Edge branches: The EdgeNet compute and delivery network with shared Edge branches, which is a shared data center with a typical IT branch office environment with virtualized/containerized compute and storage, for a given enterprise user to secure connect at the closest Micro Edge location to the end-user.
    - This allows for a cluster of home branches and users to connect to the closest Micro Edge Site securely and dynamically, without the need for any hardware upgrades at home branch offices while reducing the number of virtual connections to an Enterprise branch office/data center without compromising on enterprise policies.
    - Home branches may have multiple broadband connections (fixed lineplus LTE/5G), which in addition to offering connection redundancy can be optimized further through Secure App Wan optimization service
- Cloud Acceleration: Every Micro Edge Site (of EdgeNet) is further optimized upstream through a shared Secure App WAN optimized connection to the closest Cloud cross connect and to individual Enterprise Data Centers or branch offices dynamically with:
    - Reliable low latency connection between neighboring Micro Edge Sites
    - Reliable low latency connections between Micro Edge Sites and Branch offices' Micro Edge sites connecting to the closest Metro Edge site for boosting cloud app performance through Alef's Edge Peering technology
- Enterprise Security: Micro Edge and Metro Edge sites can enforce individual Enterprise Security policies, with policy management interfaces that are centralized, in a multi-tenant environment.

Figure 2 shows how remote workers connect directly to Edge branches at the closest Micro Edge location on the EdgeNet compute and delivery network. These Edge branches function effectively as the Branch office for the remote worker providing compute at the Edge, application performance optimization, and secure App WAN optimization to all the locations where the Enterprise's apps or data are stored.

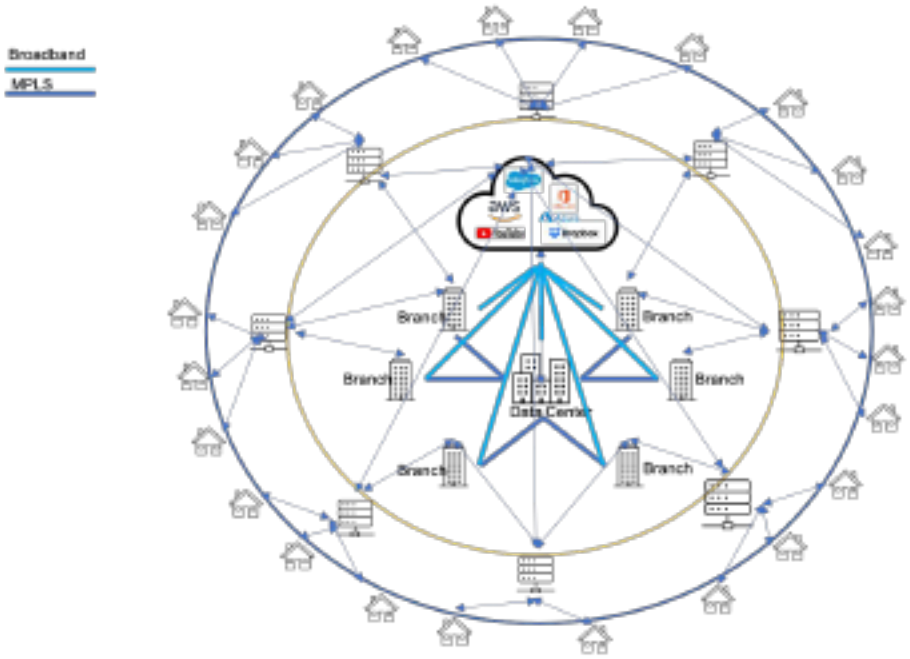

Figure 2: Work-From-Home Environment with Edge Branch Implemented

5. Platform Functions

This section describes the key features supported by the Edge Branch platform. It begins with a description of the security challenge posed by remote workers and how Alef uniquely addresses it with a modern, Edge-first, mobile SASE architecture. It then describes some of the key features supported by the platform.

5.1 Edge First Enterprise Security

- With the user accessing a traditionally perimeter protected network environment from the home office, a single user working remotely is now a vulnerability to the entire Enterprise network, with the threat landscape significantly magnified.
    - Perimeter devices such as firewalls provide security in the branch office. However, at home and mobile branches there are no such devices.
    - User devices and data are inherently vulnerable to attacks. With hundreds or thousands of remote locations, the attack surface has greatly exploded. Perimeter security principles are no longer applicable, and as a result, Trojan horse attacks, ransomware etc. will only increase.
    - The current model of Branch office security having moved to the Cloud is creating bottlenecks with the security inspection engines residing in the cloud.
    - This forces Enterprise users to go through secure locations in the cloud to access these inspection engines.
    - These centralized security paradigms have now created natural bottlenecks, as traffic is forced to flow through specific locations, translating to performance impacts and higher costs.

- With Edge Branch, programmable policy based security tied to individual application flows can be implemented on a per user basis at the Edge, as follows:
    - Each Enterprise device connects to EdgeNet using a Zero Trust (ZT) security client which then instantiates an individual Edge Branch user session.
    - A centralized Director will enable per user security policies to be programmed, while the policies are enforced dynamically at Micro Edge locations where the user is attached. This facilitates a security perimeter for the user wherever the user is, and not generically for the Enterprise network at a centralized location. Programmable security features include:
        - Secure App Wan Optimization on per user per app flow basis.
        - “Firewall at the Edge” with policies that are programmed centrally yet enforced locally at the Edge.
        - Secure DNS functions for Edge and Cloud workloads.
        - Secure Web Gateways at the Edge with policies that are programmed centrally yet enforced locally at the Edge.

5.2 Additional Key Features

Some of the additional key platform features of Edge Branch are listed below:

- An Edge Client for policy based, automated and on-demand secure connection to the Edge Branch at the Micro Edge
- Specialized application specific programmable routing
- Programmable Edge Area Networking Functions
- Wi-Fi/4G/5G related mobility user-plane functions with a centralized control plane
- Secure Mobile Breakout for application performance and low latency
- Automation through network programmability
- App Micro-Services (Enterprise workloads) instantiated on-demand through a Dev Ops pipeline, with Enterprise policies to determine what gets moved to the Edge
- All the above, managed centrally with single pane of glass data Visualization
- Open, programmable, Edge API framework for a Developer Ecosystem

6. Typical Edge Branch Use Cases

In addition to being a shared on-demand Branch Office, some additional Edge Branch use cases that can be supported are described below:

- Virtual Desktop Interface (VDI)/Desktop-as-a-Service (DaaS)
    - Hosting the application locally greatly improves the performance of the DaaS application.
    - An intuitive and seamless user experience (UX) can be delivered on any device, allowing employees access to their workspace from anywhere, on any device, at any time.
    - In addition, enhanced data security is provided with tools available to help Enterprises monitor and secure applications, desktops and data in multi-cloud environments.
    - The Edge Branch platform allows Enterprises to scale IT infrastructure on-demand, enabling them to quickly adapt to continuous workplace changes and demands for new applications or desktop types.

- Fast Access to Commonly used Enterprise Cloud Applications via a Cross Connect using Alef Boost
    - Alef's Edge Branch platform supports multi-cloud deployments by offering fast, scalable, and reliable access to corporate applications from virtually anywhere.
    - Applications and microservices hosted on AWS, Azure, GCP, Salesforce, Box.com, Dropbox, Atlassian, etc. can benefit from these cross-connects.

- Zoom and Microsoft Teams Optimization
    - Better performance and lower latency from the Micro Edge.

- Software Patch Management
    - IT Managers spend a lot of time and energy on updating their Enterprise users' laptops (both Windows and MACs) and mobile devices with the latest software updates and patches. Enterprises usually have a dedicated patch management system, which can be managed and administered from an Edge Branch location.

- VPN Replacement
    - Replacement of VPNs with Zero Trust Security and secured AppWAN at the edge.

- Developer Ecosystem
    - In addition, there will be new use cases and applications on the Edge Branch platform written by Application Developers and Network Programmers using Alef's open and programmable API architecture.

7. Reference Design

The figure below shows the Reference Design as applicable to one location of Edge Branch in EdgeNet. The components in Grey represent EdgeNet core components, while the components in Green, Yellow, Blue and Peach are programmable. Each one of these components is described in the next section based on their placement and location in the overall Alef EdgeNet network.

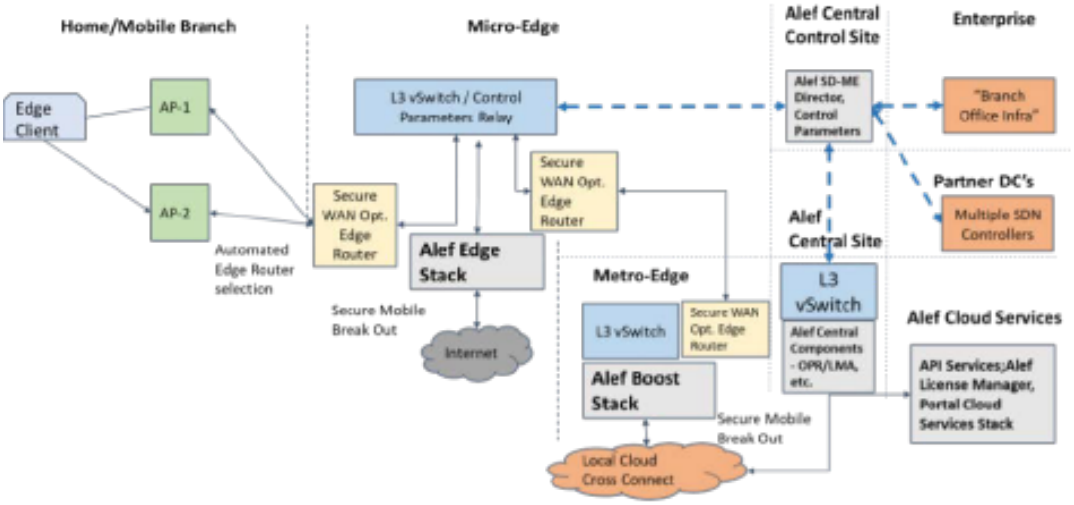

Figure 3: Reference Design for Edge Branch

The various software components in the Reference Design address several key features, some of which are found in today's modern, cloud-based software platforms. The table below lists these features and maps the various components to each feature:

Key Features	EdgeNet Core Components				Value Added Components	
	Alef Edge Stack	Alef Central Software	Alef Cloud Services	Alef Boost Stack	vSwitch	Secure App WAN Edge Router
Automation	X	X	X	X	X	X
Cloud Native	X		X			
Abstraction for Integration Automation	X	X	X	X	X	X
High Availability	X	N/A	X	X	X	
Application Performance	X	N/A	N/A	X	N/A	
Ops, Monitoring & Management	X	X	X	X	X	
Secure Local Breakout	X			X		
Secure WAN Optimization						X
Native Applications at the Edge	X					
Third Party Applications at the Edge	X					
Edge First Security	X	X				
Edge Mobility, Edge Roaming (Roadmap)	X	X				
Open Programmable API Architecture	X	X	X	X		

Table 1: Key Features Supported by Edge Branch Components

8. EdgeNet Components

While we leverage EdgeNet and the underlying architecture, as outlined in the previous section, the software and technology components that are part of the Edge Branch Reference Design are in a few key areas:

- Home/Mobile Branch[6] – The home/mobile branch connects to the closest Micro Edge via an Edge Client[7]
- Micro Edge – Collection of Micro-Edge Sites[8] that are networked together to create an interconnected network of Private networks
- Metro Edge – Collection of Metro-Edge Sites[9] (can be at major co-location data centers where well-known cloud server farms are located) where EdgeNet cross-connects with existing Cloud servers
- Alef Central Control Site, Central Site – place where some of Alef's Central software services are hosted
- Enterprise Branch Location – this will vary based on the Enterprise
- Partner Data Centers – Data Centers chosen by various software defined partners to host their controllers
- Alef Cloud Services – some of Alef's Cloud native software components such as the Enterprise subscription portal, API Gateway, License Manager, etc. are in a HyperCloud location

The key components in the Edge Branch Reference Design can be broken down into the following categories shown in the table below:

	EDGENET CORE COMPONENTS	VALUE ADDED COMPONENTS
HOME/MOBILE BRANCH	-None	- Edge Client
MICRO EDGE	-Alef Edge Software Stack, -Virtualized SDN based switching	-Secure WAN Edge Router - Zero Trust Engine
METRO EDGE	-Alef Boost Software Stack -Virtualized SDN based switching	-Secure WAN Edge Router - Zero Trust Engine
ALEF CENTRAL CONTROL SITE	-EdgeNet Control Plane Software with embedded networking	-None
ALEF CENTRAL SITE	-EdgeNet Central Software Components -Virtualized SDN based switching	- Zero Trust Engine
ENTERPRISE BRANCH LOCATION	-None	- Branch Office Infrastructure
PARTNER DATA CENTERS	-None	-Various Controllers
AWS OR OTHER CLOUD LOCATIONS	- EdgeNet Cloud Services Software	

Table 2: Key Edge Branch Components by Location

[6] Home/mobile branch – a remote office, could be in the home or a mobile office
[7] Edge Client – a Client that goes into a mobile device or laptop, managed by a Controller, and allows for the creation of policies to direct specific traffic flows to the closest Micro Edge site [8] Micro Edge site - a data center (DC) that is close to the Enterprise workload; it could be a campus or an Edge DC
[9] Metro Edge site - A DC that is further out from a Micro Edge site or DC, in a metropolitan area, typically hosting an Internet Exchange Point (IXP)

9. Illustrative Quick Start Guide for Enterprises

9.1 EdgeNet

EdgeNet comprises a growing list of Micro Edge as well as Metro Edge sites and Central sites. This increasing number of sites will each have the appropriate environment as well as Alef software components present. The choices of available Micro Edge sites and purchasing subscriptions to services available in each can be made through a convenient do-it-yourself (DIY) portal. An illustrative procedure for how an Enterprise can connect to EdgeNet and subscribe to Edge Branch is outlined below.

9.2 Enterprise Onboarding

Enterprises can purchase the Edge Branch product with a Credit Card and a few clicks on Alef's subscription portal, very similar to purchasing any Cloud SaaS product today. The Alef portal is available to, and can be customized for, direct sales as well as Alef Partners. The Enterprise user onboarding process, once a subscription has been purchased, is straightforward and easy. The workflow diagram below shows a specific example of how the entire Enterprise onboarding process would work using an Edge Client.

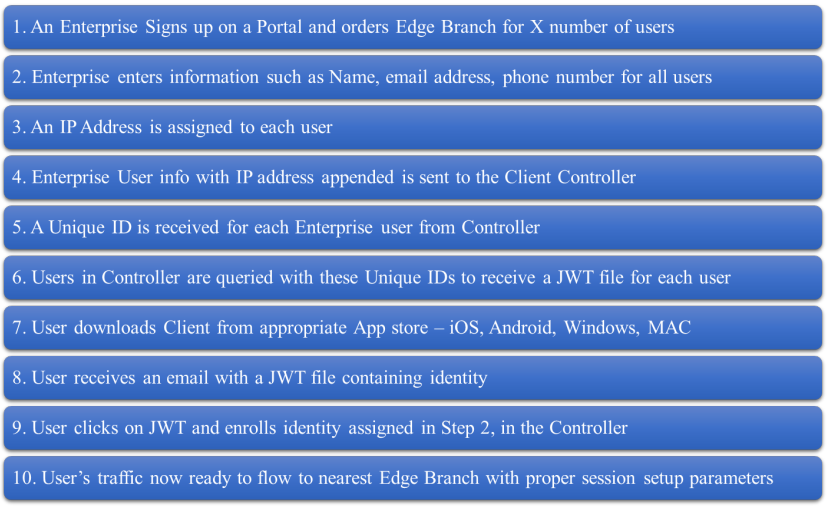

Figure 4: Enterprise Onboarding & User Session Creation

9.3 User Client Installation

The installation process of an Alef partner's Client is reiterated below:

1. User downloads ZT client from an appropriate App store
2. User receives a token required to complete the installation of the ZT client
3. User enrolls its identity onto the controller in the cloud
4. Service routing rules are configured by the controller onto the ZT client, allowing it to route traffic to the Micro Edge

10. Conclusion

Current Enterprise branch office architectures are optimized for fixed-line private enterprises, for on-premise and cloud-based workloads. As end users and devices embrace portability/mobility and roaming in the midst of a pandemic and get ready for a post pandemic world and Enterprises adopt the next generation of applications, such optimizations do not suffice, and new disruptive architectural approaches are critical.

This paper focused on a next generation 5G Edge Service based architecture with an end-to-end solution, Edge Branch, that is implemented on EdgeNet. In particular, this architecture addresses the burning problem surrounding the realities of the pandemic and post-pandemic world. The architecture allows for an on-demand and proximate branch office that is App WAN optimized, supports end-user Mobility, reliably, enforces Enterprise Security policies on traffic flows at the Edge, and provides low-latency Edge performance for the remote worker. Application performance optimization is further achieved using programmable ingredients and benefits of a typical 5G Edge Service. An illustrative quick start guide is included, with a view towards ease of custom design and programmable implementation for the challenging problem of making remote work resemble that from a Branch office location, especially in a pandemic world where an increasing number of companies are allowing their employees to work from home. Edge Branch greatly simplifies IT operations and management for Branch Offices.

Edge Branch – next generation 5G Edge Service

- End-to-end solution
- Implemented on EdgeNet
- App WAN Optimized
- Reliable
- Secure
- Programmable

Getting Started

Edge Branch can easily be deployed in minutes. To find out more about Edge Branch and related offerings from Alef, please visit our website.

For more pointed questions about the platform, please contact us through our website or through your sales representative.

About AlefEdge

AlefEdge, the innovator behind the 5G Edge Internet, delivers the superpowers of a programmable 5G Edge to developers and enterprises through The 5G Edge API. Responding to trends of Internet decentralization, Alef has integrated mobile networking with Edge computing in its flagship platform EdgeNet. By abstracting the complexity of 5G, EdgeNet unleashes a massive Edge Internet economy by securely enabling developers to build 5G Edge services that include artificial intelligence, the Internet of Things, Industry 4.0 manufacturing, smart cities, virtual and augmented reality, and more.

AlefEdge is headquartered in New York City, with offices in India and Brazil.