WHITE PAPER

Smart Cities
Intelligent Traffic Management

Intelligent Traffic Management Edge Analytics

Wipro Intelligent Traffic Management (ITM) provides edge analytics to enable real-time traffic monitoring. The solution utilizes OpenNESS.

Introduction

More cars are on the road than ever before, which, combined with aging infrastructure, is making traffic conditions in urban environments considerably worse each year. Roads and highways are plagued with congestion, causing slow movement and long commutes. Drivers are distracted by smartphones despite new laws that aim to limit this distracted driving. Additionally, pedestrian traffic, accidents, and traffic rule violations all add to challenging traffic conditions.

Given these deteriorating traffic conditions, there is a critical need for automatically detecting traffic law violations, processing these violations at the edge, and enabling guaranteed electronic delivery of the traffic violation report to the traffic police in real time.

Traditionally the traffic management system is run in the cloud, where the server is hosted. For high-precision video analytics, high quality video traffic is sent to this server and analyzed. The round-trip delay to a central cloud server and back adds to latency, and the backhaul traffic over internet links lack service level agreements (SLAs) for predictable performance. High-throughput 5G networks are enabling edge analytics, allowing the processing of video streams locally to minimize backhaul traffic.

Intelligent traffic management (ITM) solutions are being implemented into urban transportation infrastructure and into vehicles to improve traffic flow and help ensure the safety of drivers and pedestrians. A key enabling technology is video surveillance of high traffic areas, which allows government transportation employees to monitor road conditions so that public safety officers can better respond to and manage incidents and traffic flow.

ITM systems examine this traffic video footage using video analytics to classify the traffic based on a set of configured rules. This classification is used to detect violation of the configured rules. The ITM solution can cross-correlate the violation with personal identification, if permitted by law. An alert notification/output report of defaulters is then sent to the central monitoring office, where fines are imposed.

Wipro, an Intel® Network Builders ecosystem member and Intel® Network Builders Edge Partner, has developed an ITM solution that utilizes an edge analytics application running on the Open Network Edge Services Software (OpenNESS) platform deployed on multi-access edge computing (MEC) servers. The Intel® Distribution of OpenVINO™ toolkit is also used to accelerate the ITM video analytics solution.

OpenNESS Overview

OpenNESS is an open source software toolkit that enables highly optimized and performant edge platforms to onboard and manage applications and services with cloud-like agility across any type of network.

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Wipro uses OpenNESS to add orchestration features to its network edge–deployed ITM software. The Wipro ITM solution leverages the ability of OpenNESS to deploy and manage the onboarding of traffic video analysis VNFs. OpenNESS provides application lifecycle management features that can be deployed and managed on different edge servers located on premises or at the telco network edge. The service orchestration capability of OpenNESS enables deployment of the solution at scale by orchestrating with multiple edge instances of the service based on the need. A learning model obtained from one node can be propagated across all instances of the service.

Some of the key services and features that are provided by OpenNESS in Wipro's ITM solution include the following:

- **Support for multiple access technologies:** Works with 5G, LTE, Wi-Fi, and wired networks.
- **Edge orchestration:** Exposes northbound APIs that a central orchestrator such as ONAP can use to federate edge orchestration.
- **Deployment:** Can be implemented at the on-premises edge or the network edge.
- **Hardware abstraction:** Supports a template for resource description that simplifies deployment.

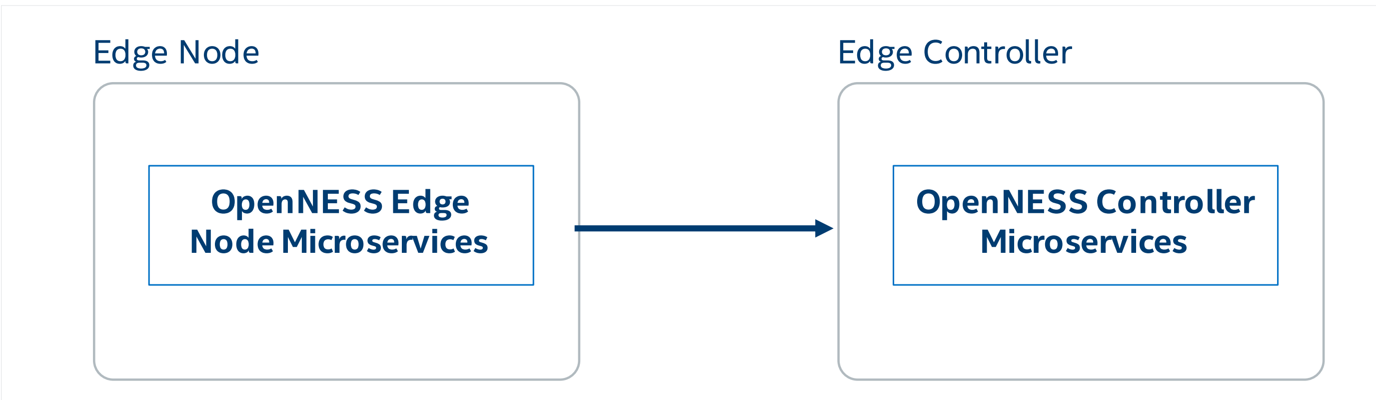

Figure 1. OpenNESS overview.

An OpenNESS subsystem consists of one or more OpenNESS edge nodes and a controller node. Both nodes host specific microservices, arranging an application's requirements as a collection of independently deployed services. An edge node hosts a set of OpenNESS microservices, edge compute applications, and network functions. The OpenNESS edge node microservices deliver the following functionality:

- Management of application lifecycles
- Enforcement of DNS and network policy
- Steering data plane traffic to edge node applications
- Steering data plane traffic to local breakout (LBO) hosts that may be attached to the edge node
- Supporting microservices or enhancements that expose platform capabilities, such as Enhanced Platform Awareness (EPA), to the edge compute applications and network functions

The OpenNESS edge node runs on a real-time kernel and leverages the open source Data Plane Development Kit (DPDK) to accelerate the data plane implementation.

The controller, depending on the deployment, either operates the edge nodes by invoking the edge node APIs or uses the existing orchestrator to manage the edge nodes. The controller exposes APIs to allow network orchestrators to operate the OpenNESS subsystem.

An OpenNESS application can be categorized as follows depending on the servicing of end user traffic:

- Producer application: Provides services to other applications running on the edge compute platform. Producer applications do not serve end user traffic directly.
- Consumer application: Serves end users traffic directly. Consumer applications may or may not subscribe to the services from other producer applications on the edge node.

Wipro's ITM services the end user traffic and therefore uses the consumer application deployment option of OpenNESS. This producer/consumer categorization allows a service subscription-based application architecture.

OpenNESS supports two environments for building an edge platform. The first one is based on a Kubernetes environment, where the controller services are run as part of the Kubernetes master, while the edge node's services run in the cluster worker node. The second is based on a KVM and native Docker run-time environment for the edge node, and the controller runs in a separate node. The ITM use case uses the latter environment to deploy and manage the edge applications.

Overview of Intelligent Traffic Management (ITM) by Wipro

Wipro's edge network–based ITM solution monitors urban traffic conditions through real-time video surveillance analytics. The ITM consists of the following components:

- A video analytics engine (VAE) using a traffic regulation policy database to detect traffic violations.
- A deep neural network model based on the low-latency, low-power, and lightweight MobileNet mobile-first computer vision models, and the Intel Distribution of OpenVINO toolkit for detecting vehicles in the video frames. The OpenVINO toolkit is based on convolutional neural networks (CNNs).

In the ITM solution, video data traffic is processed by a video analytics virtual application running at the edge node. Wipro has benchmarked[1] the efficiency of the OpenVINO toolkit-based edge solution with increasing frame capture rates. Figure 2 depicts just how many cars can be detected as the higher frame processing rates impact the compute power.

A single street may have many different traffic parameters, including different speed limits, a combination of stoplights and stop signs, and other traffic rule differences. Given the challenge of the myriad of different traffic rules and regulations for different streets, Wipro has developed a technique of applying dynamic traffic regulations based on the video stream received.

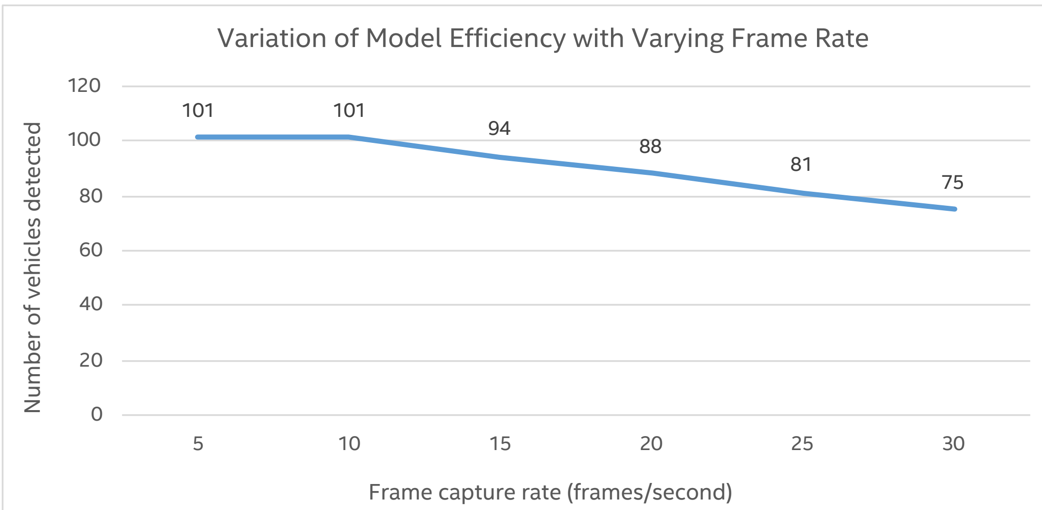

Figure 2. Wipro's benchmarking on model efficiency with increasing frames capture rate (higher is better). See backup for configuration details. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.

The video analytics engine anchors the violation detection system with a catalogue of traffic rules and regulations such as speeding, running a stop sign, going in the wrong direction, and others. This engine generates a violation report after the analytics, which is then transmitted to a central location for automatic ticket generation.

End-to-End Solution Architecture

The integration of OpenNESS into the ITM solution provides edge video analytics deployment as shown in Figure 3. The ITM application is packaged as a VM. This VM is then onboarded into the OpenNESS edge node via the OpenNESS controller. The upstream interface is connected to the video feed. The downstream interface is connected to the PDN (packet data network).

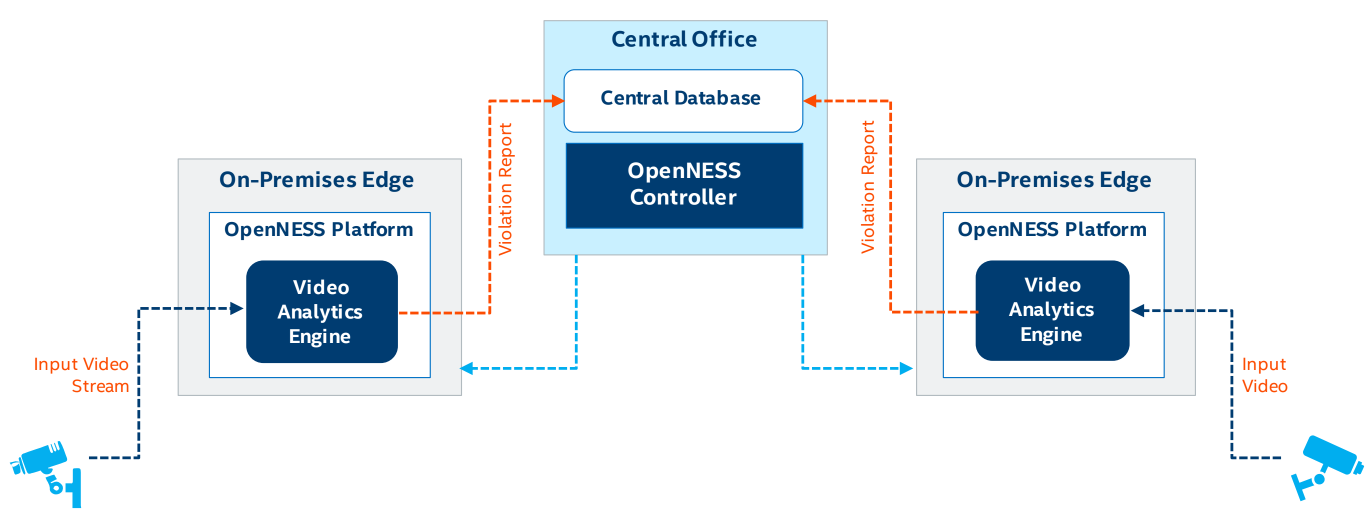

Figure 3. Block diagram of Wipro's traffic video analytics solution.

As shown in Figure 4, the edge node has four functions used for ITM implementation:

1. **OpenNESS Data Plane Services:** This steers traffic toward applications running on the edge node or the local breakout port. Traffic policies are configured on the OpenNESS edge controller and pushed to the data plane services, such that traffic steering is applied to either redirect the traffic to edge applications for further analysis or pass the packets through the downstream interface to the packet core for traffic forwarding over the packet network.
2. **OpenNESS Enhanced Platform Awareness Microservices:** These microservices include edge authentication agent (EAA), edge virtualization agent (EVA), edge lifecycle agent (ELA), syslog, DNS, and others. They manage application lifecycle, DNS resolution, application enrollment, and more.
3. **Evolved Packet Core (EPC):** The edge node is attached to the SGi interface of an EPC. Traffic from the EPC arrives as IP traffic and is steered as needed to edge applications. The EPC combines both user and control plane.
4. **ITM Application:** Video analytics engine that runs as a VM or a Docker container.

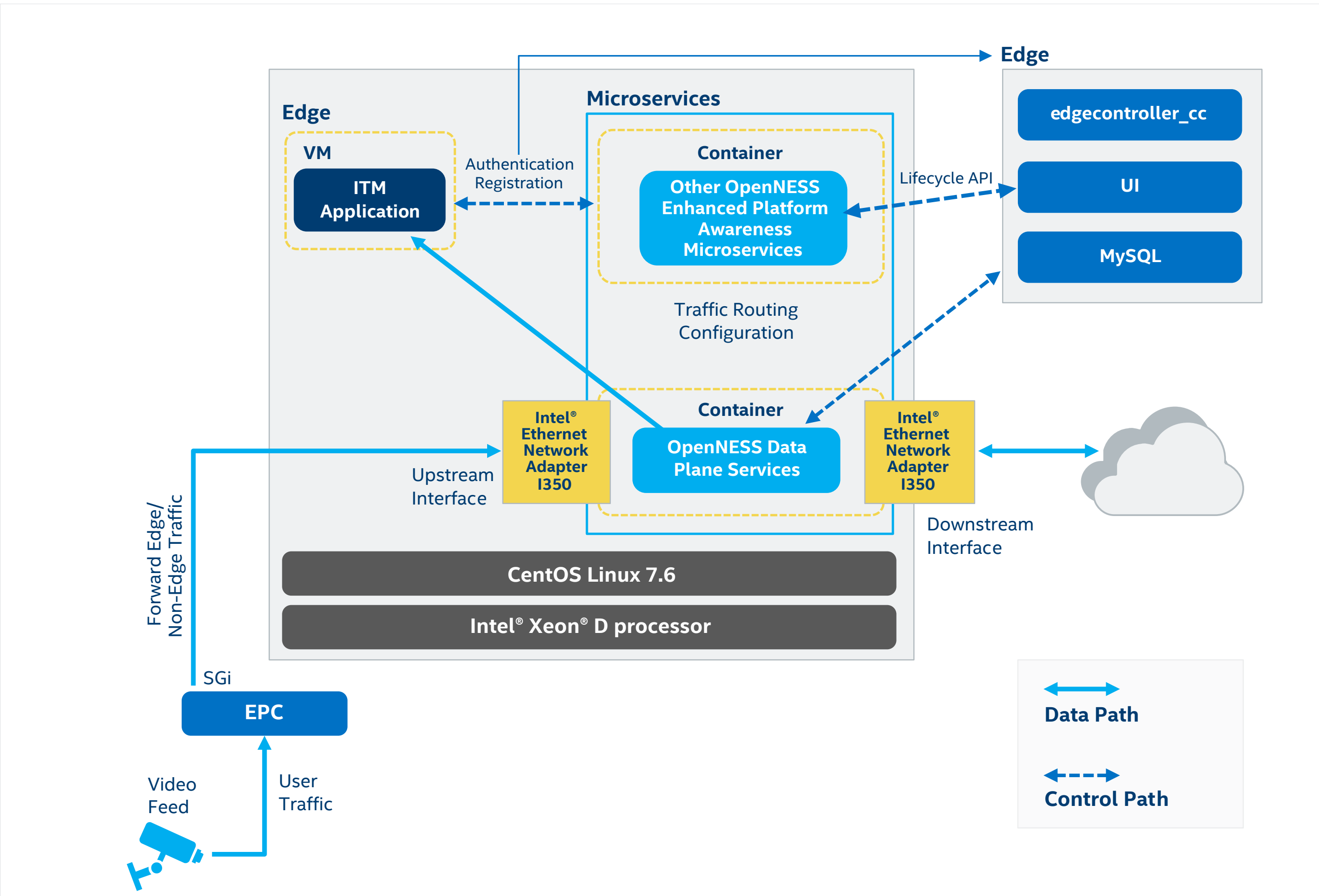

Figure 4. OpenNESS integration with ITM application.

Data and Control Flows

ITM integration with OpenNESS has two flows as shown in Figure 4.

1. **Data Flow:** As per the 3GPP standards, the video feed terminates on a base station (eNodeB for 4G or a gNodeB for 5G) and then connects to the OpenNESS edge node via an SGi interface (4G LTE) or an N6 interface (5G). In the ITM implementation, video feeds from the traffic camera reach the ITM application on the edge node through the upstream interface. The video traffic is intercepted by the data plane of the edge node data plane services. On the OpenNESS edge controller, using edge node and application lifecycle management functionality, traffic policies are configured such that traffic steering is applied to either redirect the traffic to edge applications for further analysis or pass the packets through the downstream interface to the packet core for traffic forwarding over the packet network.
2. **Control Flow:** The application is authenticated with the edge node appliance (which includes ELA, EVA, EDA, and EAA) and the edge controller. Once authentication is successful, the application is registered. In lifecycle management, the ELA communicates with the edge controller to control the status of the application (start, stop, delete, etc.). Traffic routing configuration is defined on the controller. Based on the traffic, policy routing decisions are made: incoming video camera traffic is redirected to the ITM and other traffic is sent directly to the packet core without any ITM processing.

Figure 5 shows how ITM is deployed on the edge node. Once the interfaces are declared as user plane interfaces, the ITM application VM is deployed on the edge node using the controller UI. Once the ITM VM status is changed to running state, the source filter is applied on the ITM VM to redirect traffic to the ITM application. This processing is done entirely at the edge and any detected traffic violations are sent to traffic monitoring personnel. This solution uses Intel Distribution of OpenVINO toolkit image processing libraries to process the video frames and detects speeding, wrong direction driving, or other traffic violations.

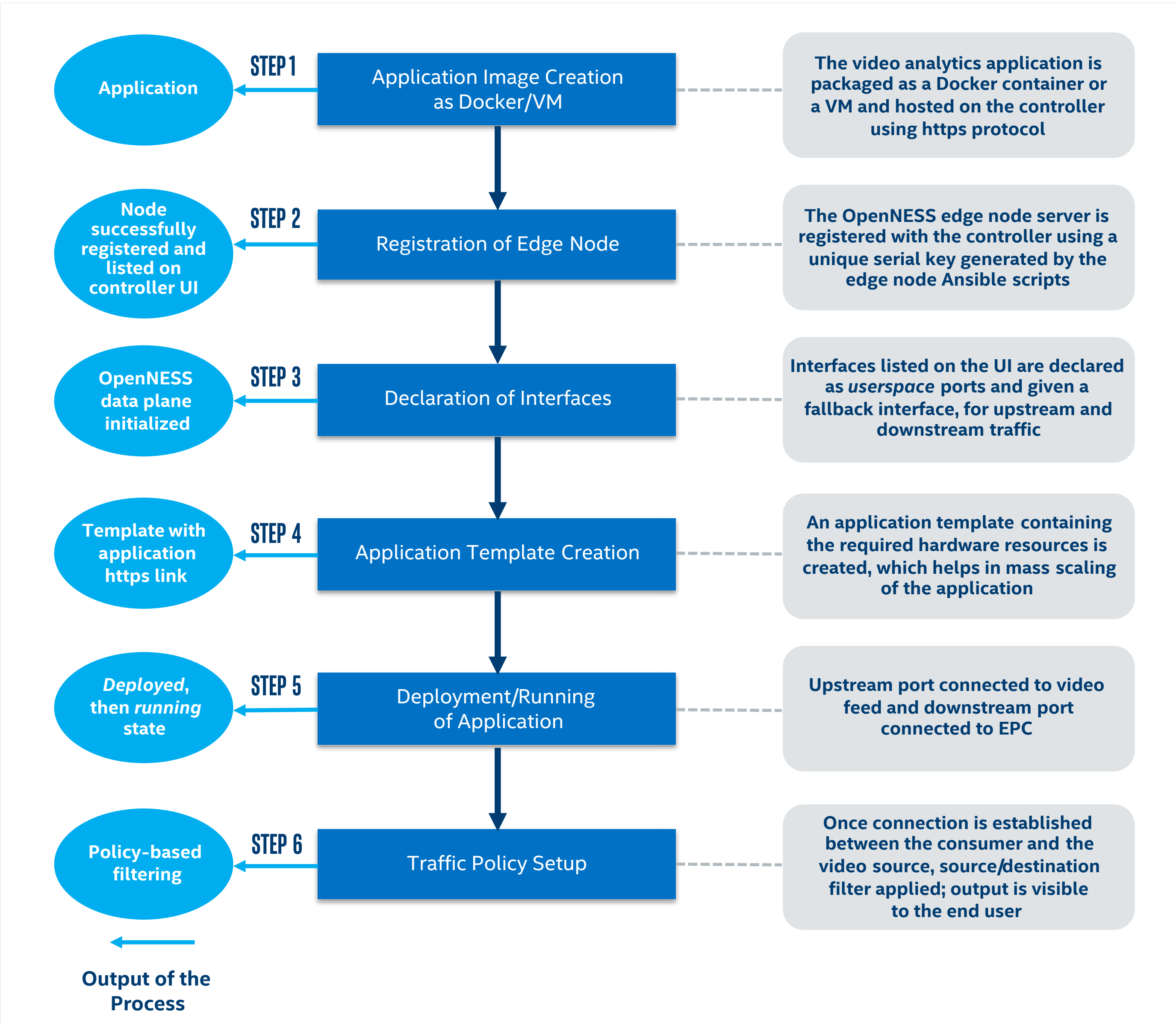

Figure 5. Flow diagram for application deployment on edge.

Conclusion

Wipro has developed the ITM solution leveraging edge analytics to utilize traffic camera networks for real-time alerts in a way that reduces backhaul network bandwidth utilization, reduces latency, and improves scalability so that the learning model obtained from one node can be propagated across all instances of the service. By using OpenNESS, the processing of the video analytics can be offloaded to edge compute nodes, allowing video processing locally to minimize backhaul traffic. Orchestration can be leveraged to replicate the ITM solution across multiple edge instances based on network size and need.

The Wipro ITM solution enables improved traffic flow and road conditions because the ITM can be trained to detect relevant activity and send an immediate alert to traffic monitoring personnel instead of transporting full video traffic to the data center for analysis. The ITM enables real-time notifications to traffic monitoring agents, providing new possibilities for better road management, critical notification during accidents, traffic violation reporting, and more.

About Wipro

Wipro Limited (NYSE: WIT, BSE: 507685, NSE: WIPRO) is a global information technology, consulting, and business process services company. It harnesses the power of cognitive computing, hyper-automation, robotics, cloud, analytics, and emerging technologies to help our clients adapt to the digital world and make them successful. A company recognized globally for its comprehensive portfolio of services, strong commitment to sustainability and good corporate citizenship, it has over 160,000 dedicated employees serving clients across six continents. Together, its employees and clients discover ideas and connect the dots to build a better and a bold new future.

About Intel® Network Builders

Intel Network Builders is an ecosystem of infrastructure, software, and technology vendors coming together with communications service providers and end users to accelerate the adoption of solutions based on network functions virtualization (NFV) and software defined networking (SDN) in telecommunications and data center networks. The Network Edge Ecosystem is a new initiative gathering ecosystem partners with a focus on accelerating network edge solutions. As an integral part of the broader Intel Network Builders program, this initiative aims to facilitate partners' access to tested and optimized solutions for network edge and cloud environments. Learn more at http://networkbuilders.intel.com/networkedgeecosystem

TABLE OF ABBREVIATIONS

3GPP	3rd Generation Partnership Project
API	Application Programming Interface
CNNs	Convolutional Neural Network
DPDK	Data Plane Development Kit
EAA	Edge Authentication Agent
EDA	Edge Dataplane Agent
ELA	Edge Lifecycle Agent
EPC	Evolved Packet Core
EVA	Edge Virtualization Agent
ITM	Intelligent Traffic Management
LTE	Long Term Evolved
MEC	Multi-Access Edge Computing
NFV	Network Functions Virtualization
ONAP	Open Networking Automation Platform
OpenNESS	Open Network Edge Services Software
SDN	Software Defined Networking
VAE	Video Analytics Engine

Notices & Disclaimers

[1] Testing conducted by Wipro in Oct. 2019: System utilized 2.10 GHz Intel® Xeon® Silver 4216 CPU (microcode 0x5000024) with 256 GB of DDR RAM, 889 GB hard drive and Intel® Ethernet Server Adapter I350T. The system BIOS was version 3.1, Intel® Hyper-Threading Technology was turned on and Intel® Turbo Boost Technology was turned off. The core OS was CentOS Linux 7 with Linux 3.10 as the kernel.

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