CAN EMTC IOT BE SUPPORTED OVER THE HFC NETWORK

A Constructional Proposal of MOVING IOT into HFC

A Technical Paper Prepared for SCTE/ISBE by

Shengbo Ge
Shanghai, China
Cable HFC/CRDC CHG/ Cisco Systems (China) Research and Development Co., Ltd
16 Floor, Block C of Keji Building, 900 Yishan Road
86-21-24014382
shge@cisco.com

Table of Contents

List of Figures

List of Tables

Introduction

This proposed solution combines eMTC wireless technology with an HFC switch node in order to leverage IoT services over the HFC network. The new designed enhanced machine type communications cellular device (eMTCell) combines with HFC switch node to transmit IoT data over The HFC network. The new designed HFC optic switch node can work as an outdoor Ethernet switch, its digital uplink fiber acts as the role of IoT mass data backhaul.

Hybrid fiber-coaxial (HFC) Network

Hybrid fiber-coaxial network is a traditional solution for broadcast video RF signal transmission that combines optical fiber and coaxial cable. It has been commonly employed globally by cable television operators since the early 1990s.

In recent years, The HFC network has gradually evolved to support high definition video on demand (VOD) services and internet broadband access services. As both digital and analog fibers are deployed between the head-end and fiber optic node in the field, the HFC network has the capability to act as the backhaul role of aggregated data from access network.

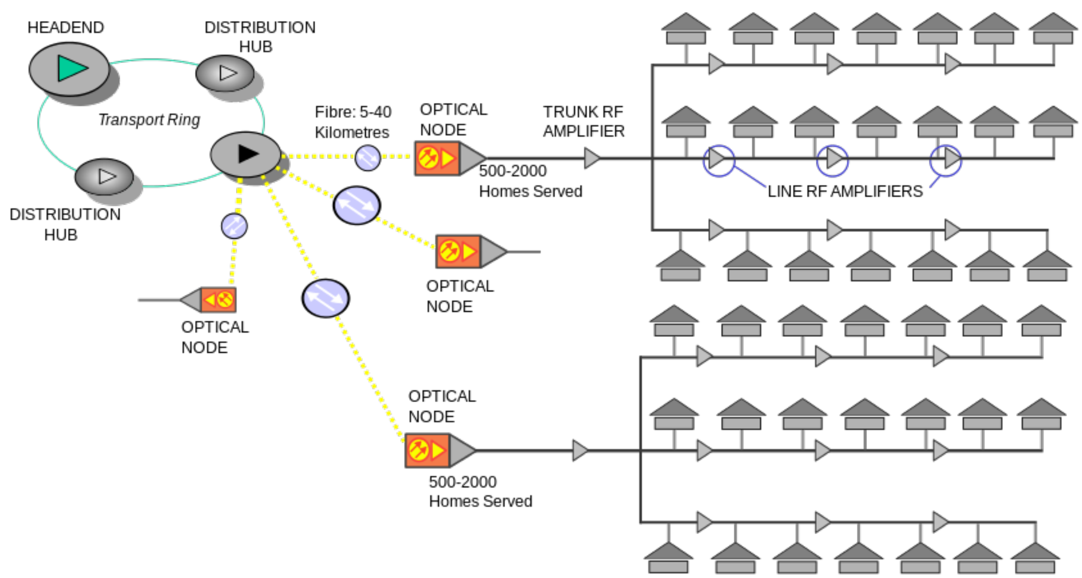

Figure 1 - A Common HFC Architecture (Source: WIKIPEDIA)

HFC Optic Node Evolves to Digital Device

A traditional linear fiber optic node has a RF optical receiver, which converts the downstream optically modulated signal coming from the head-end or hub to an electrical signal going to the homes. Today, the digital fiber optic node can work as an Ethernet switch providing broadband and narrowband access.

The optical portion of The HFC network provides a large amount of flexibility. If there are not many fiber-optic cables to the node, wavelength division multiplexing can be used to combine multiple optical signals onto the same fiber. Optical filters are used to combine and split optical wavelengths onto the single fiber.

From an architecture perspective, the HFC network provides the foundation for mass data transmission of IoT services.

Why eMTC?

NarrowBand IoT (NB-IoT) is a Low Power Wide Area Network (LPWAN) radio technology standard that has been developed to enable a wide range of devices and services to be connected using cellular telecommunications bands. {Wikipedia}

eMTC (Enhanced Machine Type Communication, often referred to as LTE-M), is part of 3GPP Release 13 and includes additional cost reduction measures, 1Mbps data rates in the uplink and downlink, and reduced transmit power.

Both NB-IoT and eMTC are typical solutions of Internet of Things mass data wireless transmission based in LTE technology. This paper focuses on eMTC as a detailed example.

	LTE Cat 1	LTE Cat 0	LTE Cat M1 (eMTC)	LTE Cat NB1 (NB-IoT)	EC-GSM-IoT
3GPP Release	Release 8	Release 12	Release 13	Release 13	Release 13
Downlink Peak Rate	10 Mbps	1 Mbps	1 Mbps	250 kbps	474 kbps (EDGE) 2 Mbps (EGPRS2B)
Uplink Peak Rate	5 Mbps	1 Mbps	1 Mbps	250 kbps (multi-tone) 20 kbps (single-tone)	474 kbps (EDGE) 2 Mbps (EGPRS2B)
Latency	50-100ms	not deployed	10ms-15ms	1.6s-10s	700ms-2s
Number of Antennas	2	1	1	1	1-2
Duplex Mode	Full Duplex	Full or Half Duplex	Full or Half Duplex	Half Duplex	Half Duplex
Device Receive Bandwidth	1.08 - 18 MHz	1.08 - 18 MHz	1.08 MHz	180 kHz	200 kHz
Receiver Chains	2 (MIMO)	1 (SISO)	1 (SISO)	1 (SISO)	1-2
Device Transmit Power	23 dBm	23 dBm	20 / 23 dBm	20 / 23 dBm	23 / 33 dBm

Figure 2 - eMTC Preliminary Specification (Source: 3GPP)

As one of the Low Power Wide Area (LPWAN) technologies, eMTC supports geolocation and mobility applications with licensed frequency spectrum, eMTC's downlink/uplink 1Mbps peak rate is higher than traditional GPRS and Zigbee.

eMTC IoT over HFC Architecture

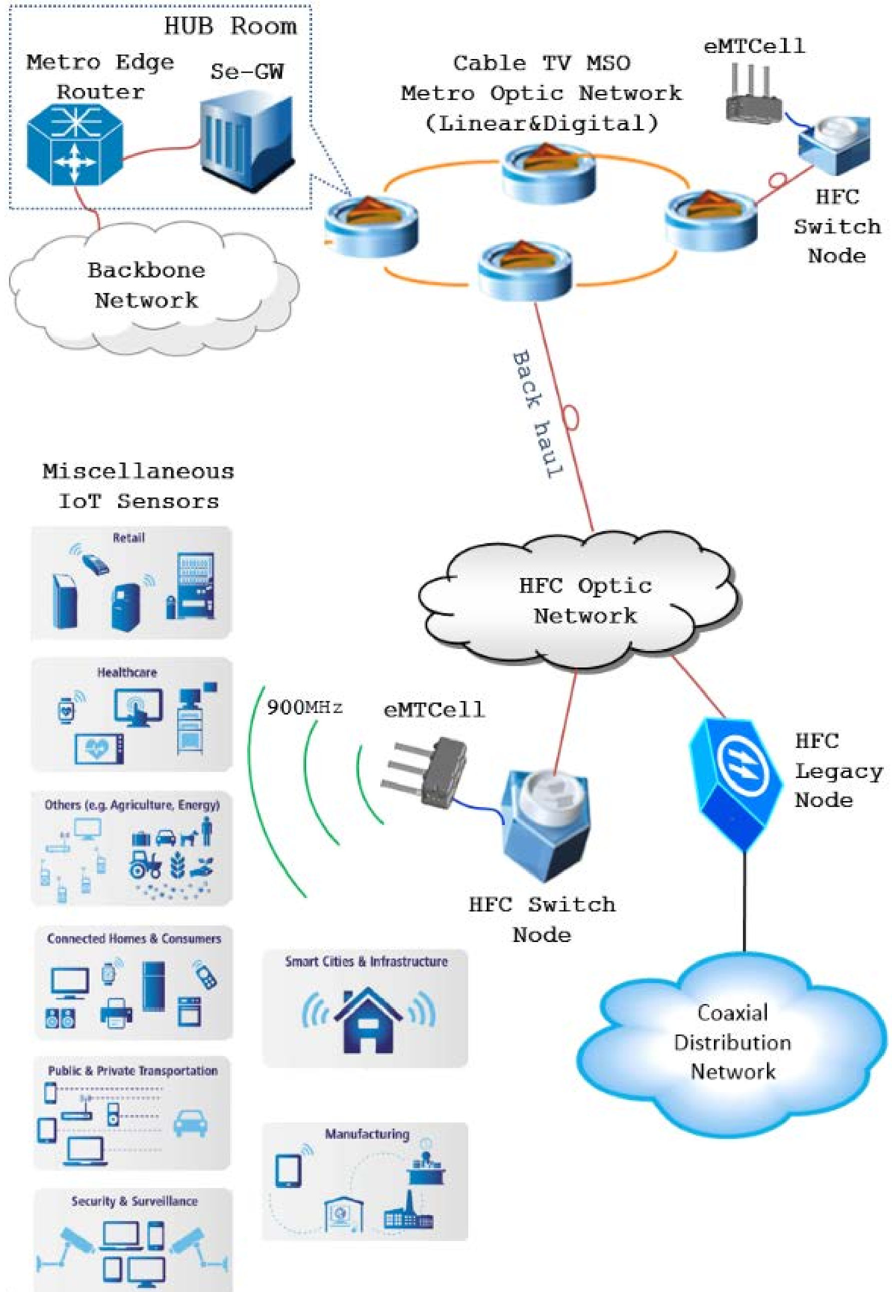

Figure 3 - eMTC over HFC Architecture

This architecture demonstrates how eMTC and IoT combine with the existing the HFC network. In many HFC networks, the fiber optic node is located within the last-mile distance to the subscribers, and eMTC technology typically covers a one mile semi-diameter area. eMTCell is considered to be designed as a standalone device nearby to the HFC fiber optic node or as a built-in module to the HFC node. eMTCell is a key device which connects IoT sensors and the HFC network, and functions like an outdoor Femtocell.

eMTCell Conception and Preliminary Specifications

To realize eMTC technology over the HFC network, a new eMTCell is to be designed, whose deployment location is outdoor and provides a 1-mile diameter coverage capability.

The proposed standalone eMTCell includes these key features:

- Compact design, easy for field installation
- Outdoor waterproof housing
- eMTC (Rel.13) standard support
- IP protocol support
- Fast Ethernet RJ45 interface
- (power over Ethernet) PoE support
- Low power consumption
- Low cost
- Remote EMS support

eMTCell is defined as: a small-sized, low power cellular wireless access device. It must connect to the nearby HFC optical fiber node's Ethernet switching module to communicate with the core broadband network. RF coverage is provided via single-input-single-output (SISO) antenna, supports access capability of up to 10,000 IoT sensors, and antenna port average transmitting power is expected to less than 5W.

The eMTC chipset or eMTC /NB IoT dual mode chipset vendors include Qualcomm, Marvell, Intel, ZTE, Sequans, MTK, Nordic and Altair. The industry predicts some chipsets being released before 3Q2018.

Table 1 – eMTCell Proposed Specifications

Housing Dimensions	
Dimensions (mm)	(compact design)
Operating Temperature	–20°C to +55°C or –4°F to +131°F
Relative Humidity	10% ~ 90%
RF Parameter	
Antenna Port Power (average)	<5W
Operating Frequency	900MHz
Receive Bandwidth	1.08MHz (carrier bandwidth 1.4MHz)
Electrical Parameter	
Power Supply	PoE , 36-90 VAC over Coax
Max. Power Consumption	TBD
Surge Voltage	2 KV（composition surge） 6 KV（ring surge）

Note- CableLabs specification controlling is recommended

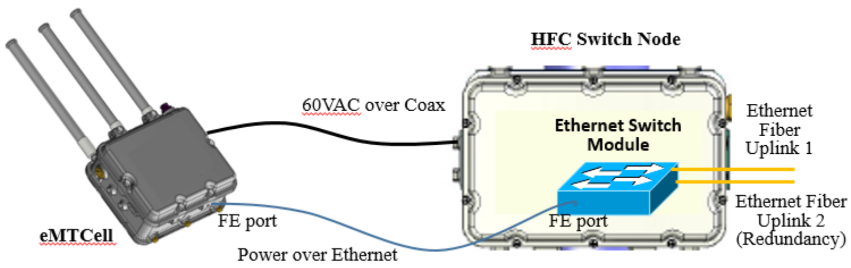

Figure 4 – eMTCell Ethernet Connection and Power Supply

HFC Switch Node Key Features

HFC switch node is the new type of HFC digital node whose typical features should include:

- Outdoor waterproof housing
- Build-in switch module which provides 10Gbps uplink capability and multiple Fast Ethernet and Gigabit Ethernet access ports
- Support RJ-45,SFP,SFP+ interfaces
- Support port-based VLAN
- I-temp switch chipset and I-temp optical transceivers
- Support PoE
- Support PoC
- Operating Temperature Range -40° F to 140° F (-40° C to 60° C)

System Functional Overview

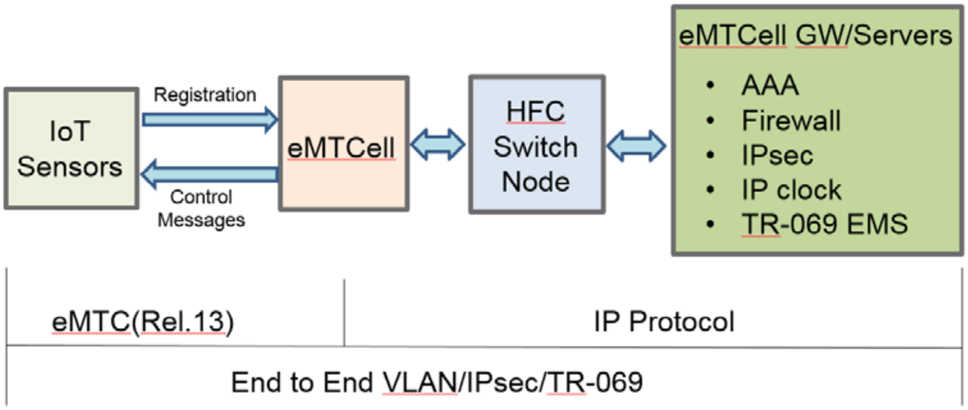

Figure 5 – System Functional Overview

The end-to-end communication mechanism includes two key protocols: eMTC protocol and IP protocol. The eMTC(Rel.13) protocol is responsible for wireless communication between IoT sensors and eMTCell. The IP protocol is responsible for communication between the eMTCell and the eMTCell gateway and relative servers.

The Security Gateway (Se-GW) in the head-end provides IoT data security. Each eMTCell builds an encrypted tunnel to the Se-GW using IPsec technology. The Se-GW supports numerous encrypted tunnels, switching users in and out of different tunnels.

Other servers are required to be responsible for authentication, authorization and accounting (AAA), IP clock, Element Management System (EMS), etc.

eMTCell over HFC Application Example

1. eMTCell Deployment

Cable industry MSOs have deployed large numbers of fiber optic nodes covering geographic regions of cities and country-sides, eMTCell devices can be paired with nearby HFC nodes (<100m) and installed on: poles, aerial strands, or on top of or on the side of buildings. The compact housing design allows easy field installation. CAT-5 shielded cable is used to connect between the eMTCell and HFC fiber optic node. eMTCell obtains power via the power over Ethernet (PoE) or power over coaxial (PoC) cables.

2. eMTCell Initiation

When the eMTCell is powered on, it detects the connection to the node and Se-GW, and obtains an IP address from the DHCP server, downloads the latest firmware image, senses the wireless surroundings, and auto-adapts the relative parameters. All of these actions are self-initiated.

If the eMTCell detects a nearby eMTCell’s signal in the same frequency, it automatically reduces the transmission power and coverage area to avoid interference.

3. IoT User Authentication Mechanism

In mobile IoT applications (e.g., intelligent watch), if an IoT sensor moves from location A to location B, the behavior triggers a re-authentication:

- In a typical application, a group ID is assigned to the eMTCell devices in the same management group, and the IoT sensor’s user ID is registered under the group ID. If the sensor moves among eMTCell devices belonging to the same group ID, the management system regards the user as legal, and re-authentication is not required.
- The eMTCell devices in the same group are assigned to the same Location Area Code and Route Area

Code. As seen from the management system, the movement among these eMTCell devices belongs to the same area.

- The eMTCell gateway monitors the mobile user's relocation behavior. If the source ID and destination ID belong to the same group, the eMTCell gateway processes the operation and sends request messages to the destination eMTCell devices. This mechanism avoids multiple re-authentication requests and terminates the inter-eMTCell requests when the user relocation happens within the same group.

Conclusion

The evolving HFC network has made it possible to support IoT services, even though the end-to-end solution will have scale and security challenges ahead.

Abbreviations

AAA	*authentication,authorization,accounting*
AP	access point
bps	bits per second
DHCP	dynamic host configuration protocol
DOCSIS	data over cable service interface specifications
EMS	element management system
eMTC	enhanced machine type communications
eMTCell	enhanced machine type communications cellular device
FEC	forward error correction
GPRS	general packet radio service
GW	gateway
HFC	hybrid fiber-coax
Hz	hertz
IOT	internet of things
ISBE	International Society of Broadband Experts
LPWAN	low power wide area network
LTE	long term evolution
MSO	multi-service operator
NB-IOT	narrow band internet of things
POC	power over coaxial
POE	power over Ethernet
RF	radio frequency
SCTE	Society of Cable Telecommunications Engineers
SFP	small form-factor pluggable
VLAN	virtual local area network
VOD	Video on demand

Bibliography & References

Hybrid Fibre Coaxial Cable; Services.eng.uts.edu.au

3GPP Low Power Wide Area Technologies; GSMA White Paper

LTE-M & 2 Other 3GPP IoT Technologies To Get Familiar With, Brian Ray; Link Labs

