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CONNECTED GRID MESH DEPLOYMENT WITH MULTIPLE VIRTUAL BRIDGES

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ABSTRACT

Techniques are described herein for a Virtual Connected Grid Module (VCGM) which can be used in a Connected Grid Mesh (CG-Mesh) deployment so as to meet smart Terminal Transformer Unit (TTU) requirements. This can balance cost and complexity very well.

DETAILED DESCRIPTION

As illustrated in Figure 1 below, in a typical Personal Area Network (PAN), a Connected Grid Mesh (CG-Mesh) generally includes one Connected Grid Router (CGR) and many Connected Grid Endpoints (CGEs). The CGR is installed with one physical Connected Grid Module (CGM) (Radio Frequency (RF) - only or Power-Line Communications (PLC) – only) or two physical CGMs (RF-only and PLC-only for dual-PHY support). Each CGM acts as a RF/PLC bridge to aggregate CGEs.

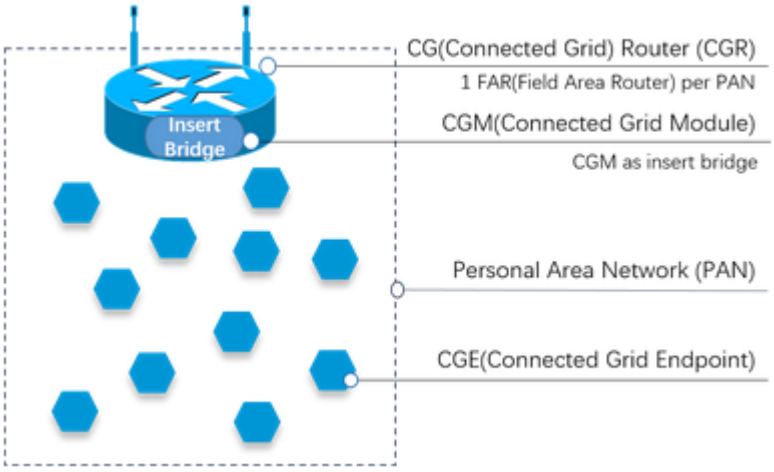

Figure 1

As illustrated in Figure 2 below, another deployment with remote CGM is also supported in which the CGR and remote CGM communicate with each other over Ethernet.

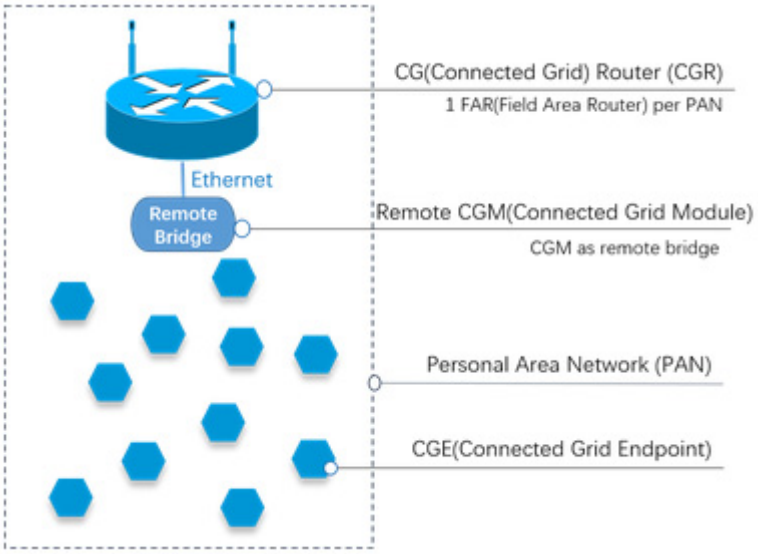

Figure 2

However, the above deployments may not satisfy a user with special requirements. For example, Figure 3 below is a typical deployment example with a Transformer Terminal Unit (TTU). The TTU receives commands from the Head End System (HES), and then forwards the command to a specified device which is under its control. In other words, the device must be in the same TTU control zone. A significant requirement of smart TTU is that it needs to have the capability to form a mesh with its controlled devices.

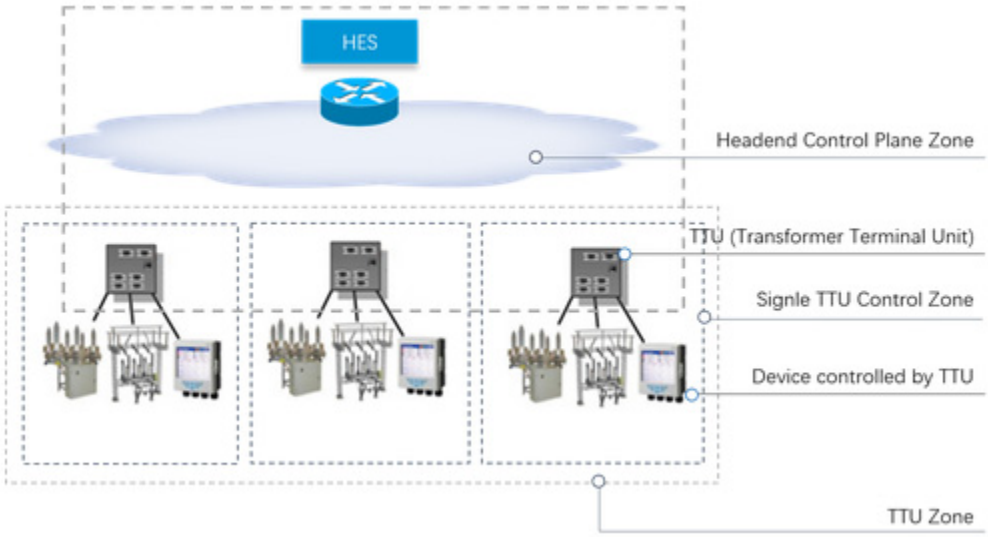

Figure 3

There are at least three straightforward solutions to support smart TTU deployment. The first solution is to treat each TTU as a CGR (CGR with inserted CGM), and each device as a CGE. As shown in Figure 4 below, this can match existing CG-Mesh deployments well. However, the cost of this solution is very high, because CGR and CGM is expensive.

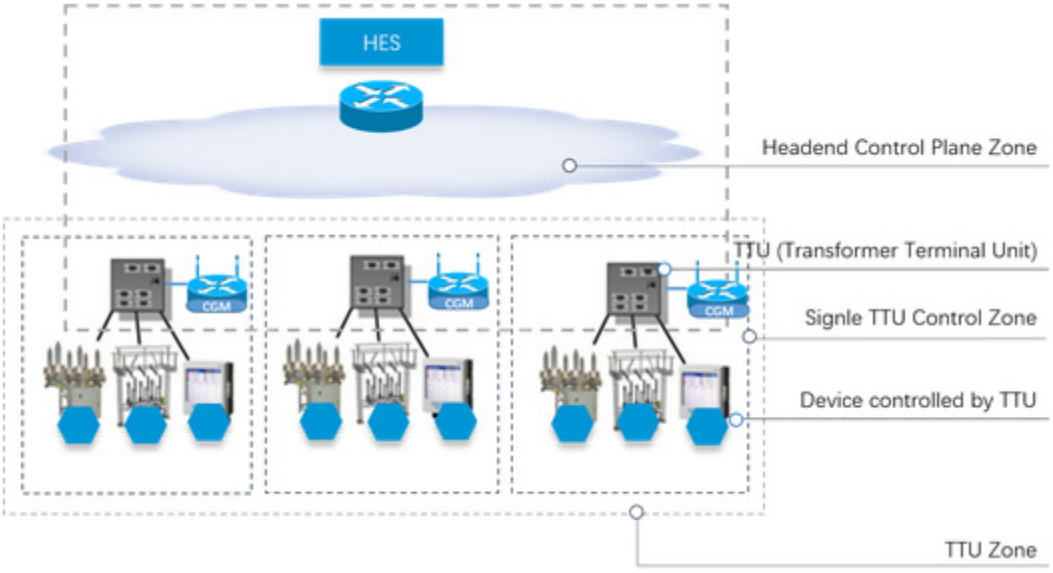

Figure 4

The second solution involves treating each TTU as a CGE, as shown in Figure 5 below. This solution reduces cost but introduces a new problem. In particular, per TTU deployment requirements, each TTU only controls devices within its control zone. But now the TTU itself is a CGE, too. This means that the TTU's role is the same are its controlled devices. Per the CG-Mesh routing mechanism, it is difficult for the TTU to distinguish the device's attribution. According to Routing Protocol for Low-power and Lossy Networks (RPL), a temporary Directed Acyclic Graph (DAG) may be created by the root from each TTU. However, this introduces significant complexity for RPL implementation.

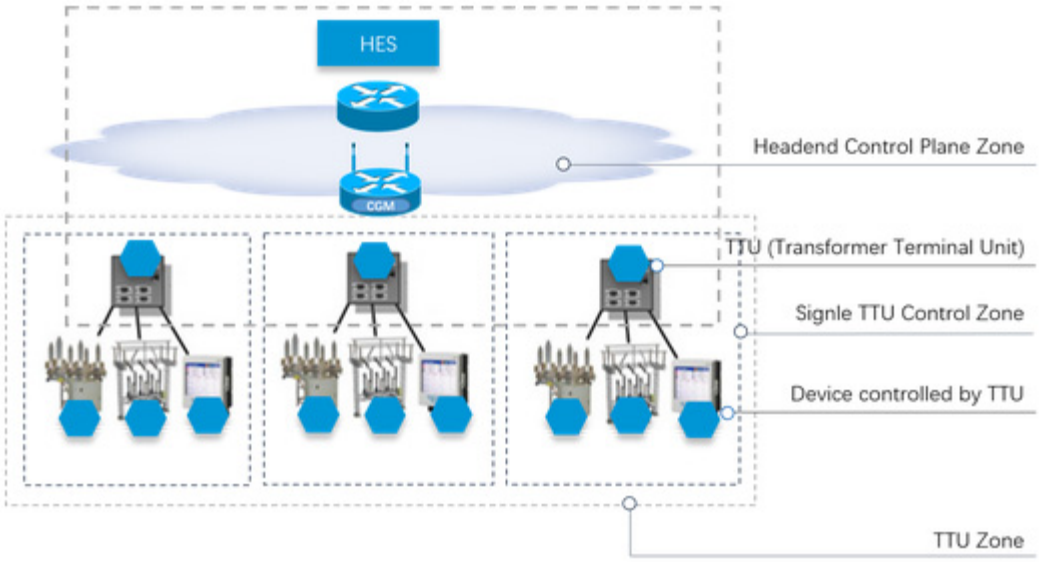

Figure 5

The third solution is to treat each TTU as the remote CGM, as shown in Figure 6 below. However, this solution also introduces problems, including increased cost of remote CGMs, interaction between TTU and remote CGMs, etc.

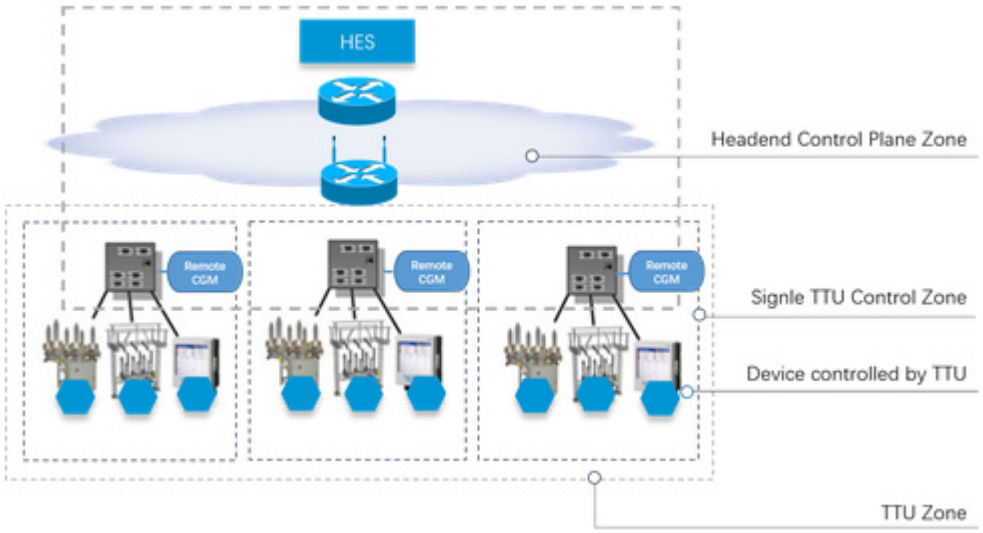

Figure 6

As such, provided is a CG-Mesh deployment solution that can meet TTU requirements. This solution may balance cost and complexity very well. Briefly, each smart TTU is treated as a virtual bridge, and each controlled device is treated as a CGE.

Figure 7 below shows a typical architecture of a smart TTU. There is an RF module which is used to communicate with the controlled devices (each controlled device installs an RF module, too). The General Packet Radio Services (GPRS) module is used to

communicate with the CGR and HES. The TTU main board has a Multipoint Control Unit (MCU) which runs an embedded Operating System (OS) such as Linux.

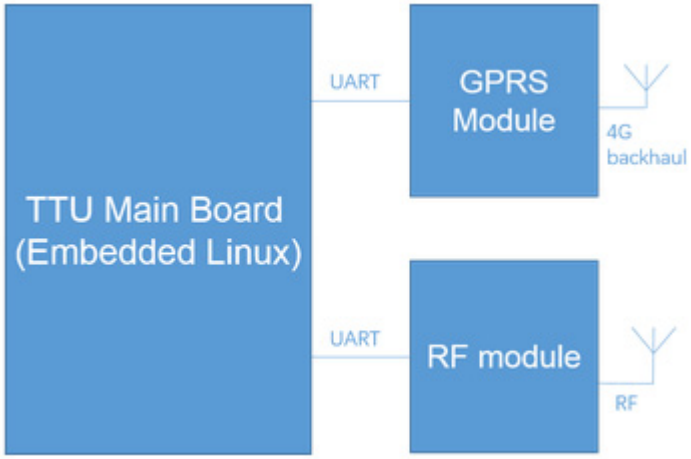

Figure 7

As described herein, the Virtual CGM (VCGM) may be treated as a bridge. The TTU has its own OS system, for example embedded Linux. An existing CGM may therefore be virtualized to run in an embedded OS system. VCGM has several special features. It has the same capabilities as existing physical CGM, and may be run in the TTU OS. It may reuse the TTU RF module so as to aggregate TTU-controlled devices. Furthermore, the VCGM may connect to the CGR over the GPRS module. There may also be multiple VCGM interfaces on the CGR. Existing CGR only supports up to two physical CGM interfaces. The CGR described herein is thus enhanced to support multiple VCGM interfaces, each VCGM interface mapping to a TTU in the field. In TTU deployment, each TTU may install a virtual CGM in its own OS. Whenever a virtual CGM is up, it registers itself to the CGR, and then the CGR generates a virtual CGM interface accordingly. Figure 8 below illustrates the improved TTU deployment.

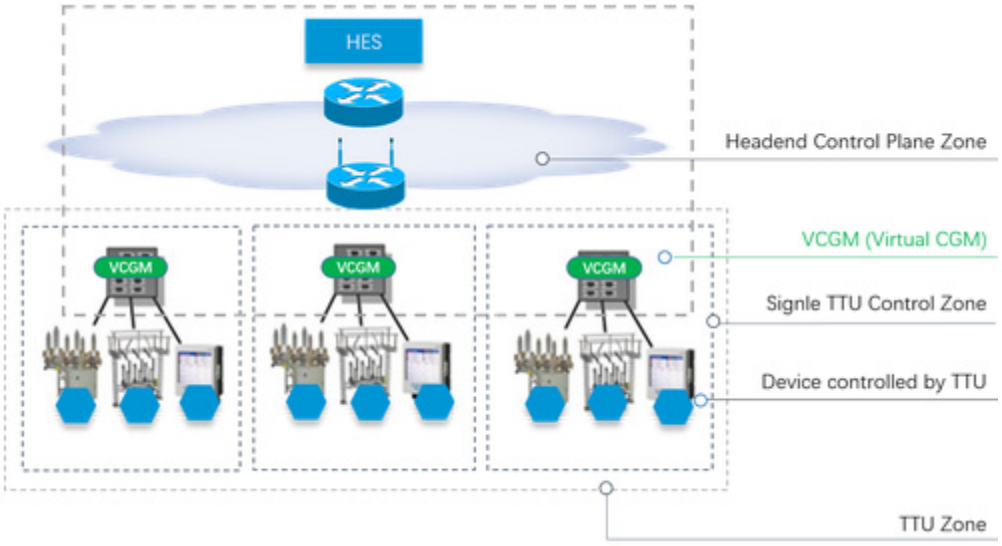

Figure 8

Figure 9 below illustrates another deployment using VCGM where the TTU can install both the Embedded Service Router (ESR) and VCGM.

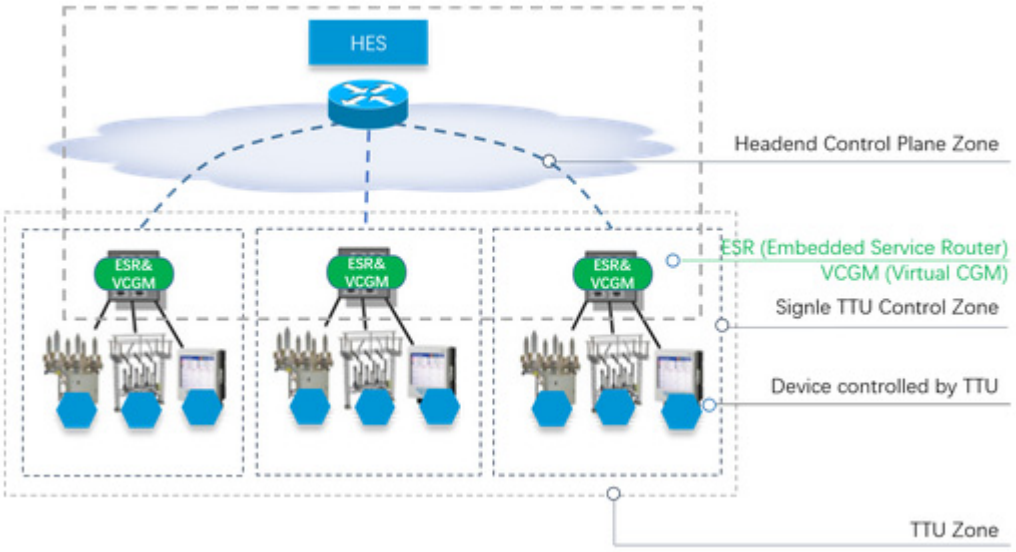

Figure 9

Both improved TTU deployments may enable each TTU control zone to map to a CG-Mesh PAN perfectly and easily control its own devices.

As described herein, a VCGM may be used instead of a physical CGM. The VCGM may be pure software running in the TTU, and may also act as a bridge to aggregate all CGEs. Furthermore, to support smart TTU deployments, multiple VCGMs may be used. All VCGMs may aggregate on a CGR. The GPRS module may be used to communicate

between the VCGM and CGR. The RF module may be used to communicate between the VCGM and CGEs, where each TTU controlled device is a CGE.

In summary, techniques are described herein for a VCGM which can be used in a CG-Mesh deployment so as to meet smart TTU requirements. This can balance cost and complexity very well.