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Present status and future road map for ITER CODAC networks and infrastructure☆

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ABSTRACT

ITER Plant Systems I&C will be connected to CODAC System via Plant System Host (PSH) and High Performance Networks (HPN). Some functions of CODAC require deterministic, hard real-time communication and synchronization between distributed nodes. These requirements are addressed by the CODAC High Performance Networks. The CODAC network infrastructure is being defined including space allocation for backbone cable termination as well as housing network equipments in different ITER plant buildings, cable trenches, network topology and backbone. The ITER building design is in final stage so the activities in this direction are quite well in advance. Many prototyping and market survey activities leading to technology decisions for High Performance Networks (HPN) have been launched in late 2008. These activities are evaluating different commercial off-the-shelf (COTS) technologies as well as technologies being used in existing fusion and non-fusion experiments. In this paper we provide the current status of activities which are ongoing to define CODAC network infrastructure as well as a report on technology decisions. Finally we provide a plan and roadmap to complete this task of defining CODAC networks and network infrastructure.

1. Introduction

CODAC is the central control system responsible for operating the ITER device. CODAC is responsible for coordinating and orchestrating the operation of 161 plant systems including plasma feedback control. CODAC networks will connect to all these plant systems to central CODAC system for different purpose.

Networks interfaces provide the physical interconnection between plant system I&C and central I&C systems [6]. The three independent tiers CODAC, Central Interlock System and Central Safety System have three independent separate networks named CODAC Networks, Central Interlock Network (CIN), and Central Safety Networks (CSN). These three networks are also called central I&C Networks. CODAC Networks, in turn, comprise general purpose Plant Operation Network (PON) and a set of specialized networks, named High Performance Networks, which consist of the Synchronous Databus Network (SDN), Time Communication Network (TCN), Event Distribution Network (EDN) and Audio/Video Network (AVN). Fig. 1 shows all central I&C Networks planned to connect ITER central I&C systems with plant systems for different purposes.

Each plant system can communicate over one or more networks depending on the required functionality, volume of data, bandwidth and latency. Networks are centrally managed by IO including assignment of network addresses. The basis of the performance requirements for above specialized CODAC networks is CODAC conceptual design [1,2]. The performance requirements for different CODAC networks are described as follows.

1.1. Plant Operation Network (PON)

PON provides asynchronous interface between plant system I&C and the CODAC system through Plant System Host PSH [7]. The Plant System Host shall be the only plant system I&C component connected to PON. Every plant system I&C shall be connected to PON.

1.2. Synchronous Databus Network (SDN)

SDN is responsible to provide real-time data exchange between different plant systems and also for fast real-time plasma control system (sampling frequencies in the kHz range). The important requirement is to provide deterministic communication of the order of 1 ms. The expected number of nodes is in the order of 50. Another constraint is to provide a guaranteed data transfer of 5000 signal values (8 bytes per signal) in 1 ms with 0.01 ms RMS jitter. These performance requirements are based on CODAC conceptual design report and are currently challenged.

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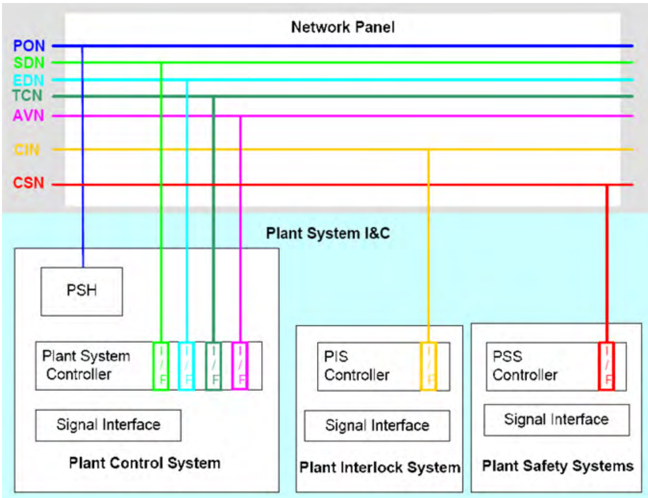

Fig. 1. Network interfaces between plant system I&C and central I&C systems.

1.3. Time Communication Network (TCN)

TCN provides project-wide time synchronization with an accuracy of 10 ns RMS. The official ITER project time is UTC. Only plant system I&C requiring high accuracy time synchronization shall be connected to TCN. Plant system I&C may have multiple TCN network interfaces.

1.4. Event Distribution Network (EDN)

EDN provides event distribution between plant systems I&C and the CODAC system with latency of less than 10 μs RMS. Only plant system I&C generating or receiving events with this accuracy shall be connected to EDN. Plant system I&C may have multiple EDN network interfaces.

1.5. Audio/Video Network (AVN)

AVN provides communication for audio and video signals. The purpose of AVN is to transmit different diagnostic data for real-time visualization as well as for surveillance purposes. AVN should have 30 frames/s with 1024×1024 frame size data source rate with 120 nodes for surveillance and at least 20 nodes for diagnostics video data. Only plant system I&C generating audio and video signals shall be connected to AVN. Plant system I&C may have multiple AVN network interfaces.

2. CODAC infrastructure

Many ITER buildings will house plant system I&C which needs to be connect with central I&C systems through different networks. In order to implement all networks mentioned in Section 1 there is a requirement to connect these ITER buildings with CODAC server room in control building and IT server room in another building with a set of cables. It has been decided to use dual star topology for all CODAC networks. The CODAC infrastructure in ITER plant buildings is being planned based on this decision [4]. The main or primary star point for ITER CODAC Network will be implementing in the control building. A secondary star point will be implementing in the IT server room in another building. All buildings are connected to both star points for all CODAC networks with redundant set of cables with separate path. The main star point in control building and secondary star point in IT server room are inter-connected through redundant optical fibre cable with separate path. The cabling path is being decided with minimum number of band/turn to avoid optical attenuation.

The active networking components in CODAC hutches will be fed the two trains of UPS power backed up with additional Diesel Generator power supply for high availability.

Fig. 2 shows the typical layout of CODAC infrastructure. CODAC network hutch is a closed area equipped with heating, ventilation and air conditioning and adequate uninterruptible power housing a set of cubicles, which will accommodate the active and passive components for plant system I&C networks. According to geographical location many ITER buildings on site will house one or several network hutches. The network hutch connects to the site network infrastructure and network panels. Fig. 3 shows the main star point for all networks and CODAC network hutches distributed over ITER site. Small wall-mount lockable patch panels as shown in Fig. 2 are being planned to be installed near the plant system I&C cubicles.

3. CODAC current actions

This year following activities have been initiated in order to be getting ready for the detailed design and procurement of network infrastructure. The ITER design choices and prescribed standards are based on independent market surveys, prototype activities, benchmarking and evaluations.

3.1. Ongoing CAD activities

Recently some CAD activities have been launched. Under these activities the cabling diagrams were prepared and these diagrams will define all cable segments required for different networks. The next step will be to prepare the cable routing layout for all backbone cables. The ultimate goal is to get the cable length of the segments, number of wall penetrations and bands. The above-mentioned activities will also define location and number of wall-mount CODAC network panels near the plant system I&C cubicles in different buildings. All the above outcomes will be helpful in the selection process of Physical communication media between different network segments and enable further implementation process.

3.2. CODAC High Performance Networks survey

A few tasks defined in 2008 aim to analyze the requirements of different CODAC HPN and to perform market survey to investigate potential commercial off-the-shelf technology solutions. The market survey shall address performance, cost and longevity. Under these activities a tradeoff analysis between different solutions is being performed. A few small prototypes are being built to demonstrate that performance requirements can be met. These activities will complete in this year. Some of the technologies which are being investigated for SDN are based on real-time Ethernet and shared memory. The following real-time Ethernet solutions are being investigated: Ethernet-POWERLINK, RTNet and EtherCAT. The Reflective Memory Network is being investigated for shared memory solution. The technology being investigated for TCN and EDN are IEEE-1588, Greenfield Technology and Micro-Research Finland Technology.

The CERN supported conceptual technology named White Rabbit is also being evaluated which is based on Ethernet. The current specifications obtained from open hardware repository (http://www.ohwr.org) defines a system, which provides deterministic data transfer, time distribution and event network to distribute triggers to around 1000 stations and automatically compensates for fibre lengths in the order of 10 km. This is based on 1 GB Ethernet communication link. It takes advantages of synchronous