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Remote participation in ITER exploitation—conceptual design

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ABSTRACT

The ITER facility, being built as an international collaboration, will be used by the multiple participating countries, both via their representatives on site and via remote participation. Remote access will be an integral part of the ITER control system (CODAC) and will consist of two main interface components – a data gateway serving outgoing data requests and a request gatekeeper overseeing incoming configuration requests. This paper gives an overview of the current state of the design of remote access to ITER experimentation and reports on the principal results of R&D activity on the gatekeeper functionality conducted jointly by the ITER Organization, General Atomics and MIT.

1. Introduction

One of the challenges arising from the ITER treaty is the provision of facilities for participating countries to conduct remote experimentation on the ITER machine in order to benefit fully from scientific and technological results of the ITER exploitation. Remote access will be an integral part of the ITER control system (CODAC). The first conception of the remote participation in CODAC was given in the CODAC conceptual design [1] in 2007. Since that, the ITER Organization, together with General Atomics and MIT, has executed an R&D task on the incoming request gatekeeper functionality. This paper gives an overview of the current state of the design of remote access to ITER experimentation and reports on the principal results of the study.

2. General principles and approach

Like for any other sensitive installation, for ITER there is a strong requirement that the plant operation be performed in a clearly separated space. This area is determined geographically by the so-called “nuclear perimeter”, which includes buildings of the tokamak and its services (power, cryogenic plant, cooling system, fueling, diagnostics, etc.) and has specific access control procedures applied. A standalone control building is also included in the nuclear perimeter. From the point of view of the ITER control system the part of the nuclear perimeter, which hosts computer infrastructure and equipment directly related to operation, is called a plant operation zone (POZ). The primary network of ITER operation, interconnecting CODAC and plant system instrumentation, is called a plant operation network (PON). PON interfaces to a general ITER network (GIN), which has supporting infrastructure for operation, but does not directly participate. Finally, GIN opens to a public network to provide interfaces to remote analysis and experimentation facilities. The PON and selected parts of the GIN meet each other in the control building in order to provide a full-featured experimental environment in the control room. This is illustrated in Fig. 1.

Breakdown of functions between the POZ and the rest of the ITER site is driven by a balance of two competing principles. One requires that the POZ shall be self-sufficient in order to execute the experiment (e.g., all hardware and software to run the pulse shall be a part of the POZ), so that the experimental process does not depend on events in external networks. Application of this principle usually leads to an increase in the number of computer systems within the POZ. Another principle recommends keeping the POZ computing environment as small as reasonably possible, to avoid the additional constraints of software and procedures, which a controlled area imposes, and to improve controllability of the POZ. This is why functions like plasma control and configuration database are made part of the POZ, while long-term scientific data storage and engineering databases are kept outside the POZ (but still in close vicinity on the ITER site). Off-site functions mostly include means of remote participation as well as a rich environment for pre-experiment and post-experiment analysis of the scientific data. An overview of these functions and the candidate technologies for them is given in [2,3].

Computer interfaces between the plant operation network and the general network are strictly controlled. In order to better over-

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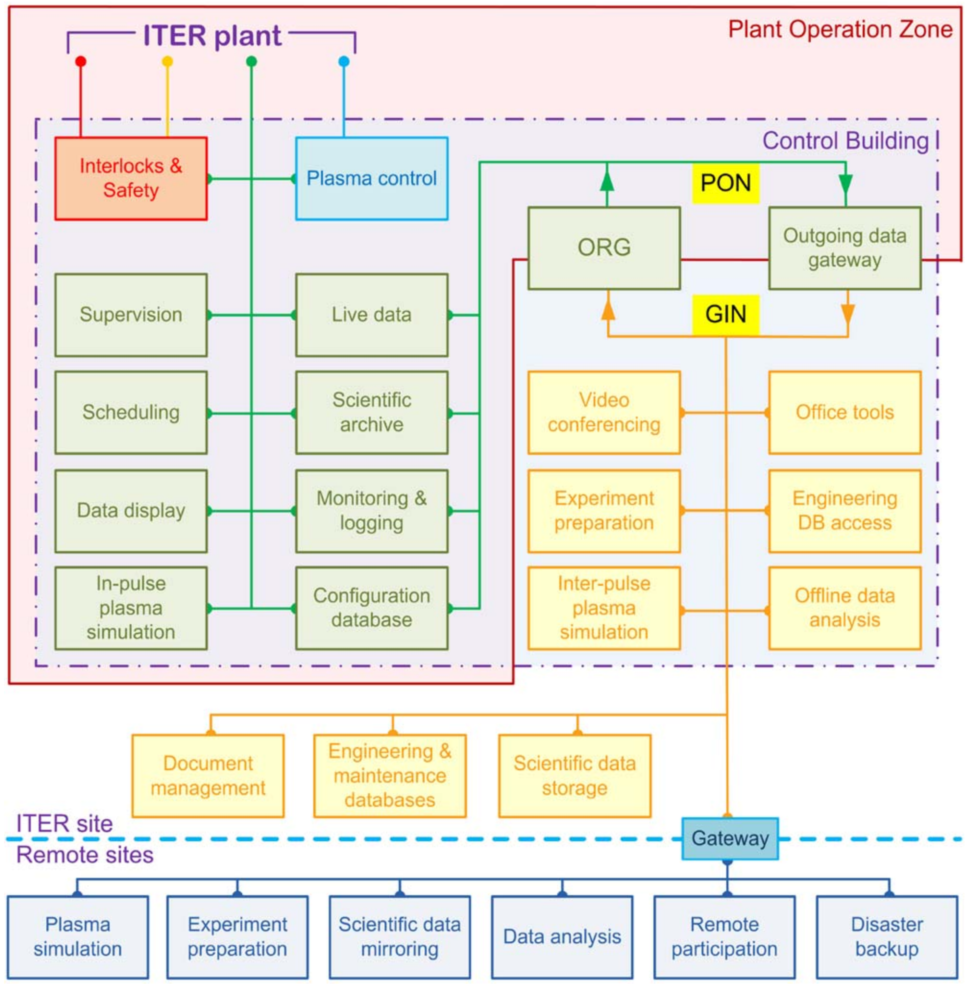

Fig. 1. Illustration of functions and their attribution to the plant operation zone, control building, ITER site, and remote sites.

see communication, these interfaces are split into two functionally different components (see Fig. 1): (a) a data gateway serving outgoing data requests, and (b) an "Operation Request Gatekeeper" (ORG) overseeing incoming configuration requests. The data gateway is targeted primarily for reading of the scientific or engineering data coming from the machine, but in principle can be used to read any sort of data out of the PON. Formats and allowed scope of such requests are configured in the CODAC system in advance. The gatekeeper, on the contrary, is oriented to incoming configuration requests, which are used primarily in the experiment preparation phase. The rest of this paper mostly deals with the gatekeeper component.

3. Operation Request Gatekeeper

ORG operation obeys several high-level requirements (see [4]):

- There shall be no automatic transfer of data of any type onto the PON from any other computer networks;
- All data loaded onto the PON shall be verified by, and under the responsibility of, an authorized individual located in the control room as if he had himself created these data;
- ORG actions shall have no effect on the safety or interlock systems of ITER.

The "no automatic transfer" principle mandates the presence of the part of the ORG outside the PON, which should take care of receiving and queuing requests before further processing is requested from the PON.

ORG operates in terms of well-defined requests. Requests are basically transactions of a nature "command – action", where action could be anything; but most often it will be a data modification in one of the CODAC databases in the POZ. Continuous incoming data streams are not currently foreseen in the design of the ORG. To facilitate verification and decrease the throughput load on the gatekeeper, it is assumed that the ORG does not return any data, but responds only with status information of the request. Requests which yield data to be read back from the PON should do it through the outgoing data gateway. This "dual" interface may be hidden behind a special programming interface facilitating exchange of information with POZ.

ORG is conceived to be an intelligent component capable of judging the nature and consequences of requests. This will ultimately help operators in the control room to classify and process requests more efficiently. Many requests can be rejected or delayed by smart verification mechanisms based on chains of logic modules. Depending upon the request, different logic modules can be invoked. The modules are supposed to return a simple "yes/no" result, thus facilitating construction and verification of the whole logical chain. The modules can be integral parts of the ORG or can be provided to the ORG by CODAC subsystems which have an interest in the remote configuration functionality. The latter case is advantageous, as it allows avoiding duplication of verification codes in the ORG and in the affected CODAC subsystems. Technically this