TTC backbone real-time monitoring

A facility and a web application for a real time monitoring of the TTC backbone status.

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Main objectives

As the reliability of the distribution of the **LHC timing signals** to the experiments is of great importance, there has been a need for a global monitoring system with a **real time and post-mortem analysis facility called TTCpage1**. This system gathers qualitative data describing the status of the timing signals all over the accelerator and makes them available anytime to the **Timing, Trigger and Control (TTC)** support team.

It also delivers a way to ensure that the designed hardware responsible for transmission of these signals is behaving as we expect.

Distribution of the timing signals — LHC TTC backbone

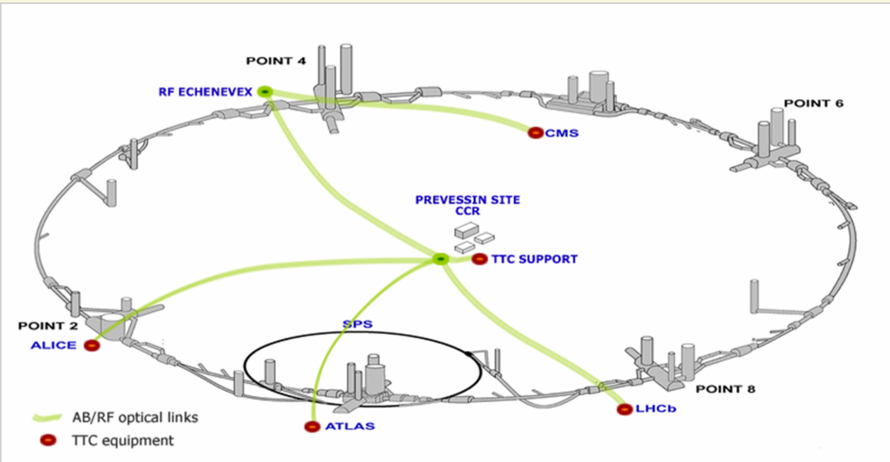

*Figure 1: **RF-TTC***

The distribution of timing signals from the LHC Radio Frequency (RF) source in Echenevex to the four experiments (ATLAS, ALICE, CMS, and LHCb) is performed by the TTC system, common to all the experiments. A copy of these signals is also transmitted to the monitoring system, installed in the Control Center in Prevessin by the authors, which provides **continuous measurement of parameters such as Bunch Clock (BC) jitter and frequency, Orbit period in BC counts and transmission delay over fiber versus temperature.**

Measurement devices and signal sources

The deployed system is based on an equipment consisting of a server PC (called TTCpage1 server), a **VMEbus processor**, a number of custom designed VME slave cards and off-the-shelf oscilloscopes installed in the Rack zone of the CERN Control Center (CCR) at the Prevessin site.

A set of applications written in C/C++ has been developed for collecting the data.

As a part of their functions the applications provide a remote control of **two oscilloscopes** accessed via TCP/IP connections and Versatile Instrument Control Protocol (VICP). The application makes use of a General Public License (GPL) based library for controlling VICP devices.

As the **Data Interchange Protocol (DIP)** is used as a source of some of the monitored signals (statuses of TTC receivers, Beam mode and temperature value), the applications have been extended with DIP libraries and some interface classes providing the ability to act as both dip-publisher and dip-subscriber.

Three high precise frequency meters based on XILINX Microblaze design and 10MHz GPS (GMT) clocks have been developed at CERN to provide high accurate frequency tracking (precision up to 1 Hz, BC ~ 40 MHz). The server communicates with the meters through an RS232 interface.

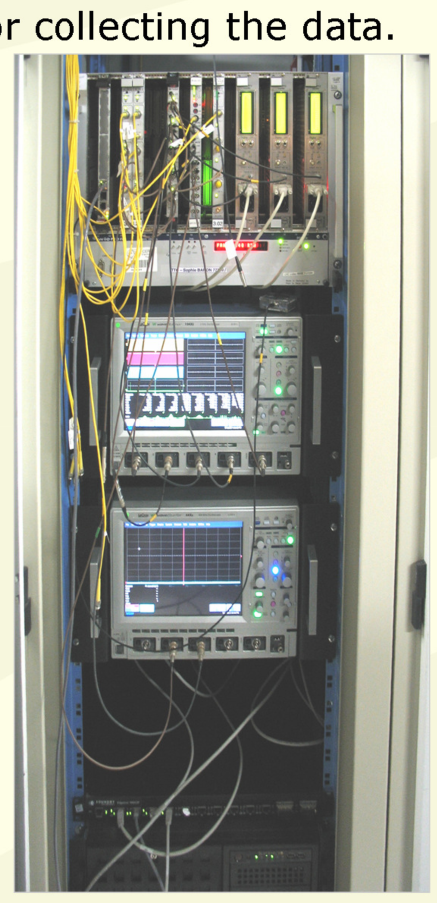

*Figure 3: **Measurement equipment** (VME crate with frequency meters, VMEbus controller and slave modules, two oscilloscopes, local network switch and Server PC)*

Emphasis has been put on ensuring **reliability and security** of the system. This includes an implementation of data buffering mechanisms in case of database connection problems, local data storage and automatic remote restart of the VMEbus controller through custom design RS232 based interface.

Email and SMS notification procedures have been added to provide fast detection of undesirable conditions and possible system failures.

What do we measure and monitor ?

The **TTC timing signals** consist of three bunch clocks (BC1, BC2 and BCREF) and two orbit signals (ORB1 and ORB2). For each ring the Bunch Clock is a square wave at the RF frequency divided by 10. Its rising edge has a fixed delay with respect to bunch passage. This delay is reproducible from run to run. When present, BCx is always locked to the corresponding beam.

*Figure 2: **RF-TTC signals***

For each ring the Orbit is a sequence of 5 ns long pulses at the Revolution Frequency. This delay is reproducible from run to run. When present, Orbitx is always locked to the corresponding beam.

The monitored parameters are extracted from these 5 timing signals.

Monitored parameters and values summary (based on 10s update rate)

Scope1 "jitterScope"	Scope2 "driftScope"	Frequency meters	VMEbus crate controller RF_RX_D and RF2TTC modules	Status of TTC backbone receivers and transmitters (DIP)
Cycle to cycle jitter: - BC1, BC2, BCREF Skew jitter: - BC1 VS BCREF - BC2 VS BCREF - BC1 VS ORB1 - BCREF VS ORB1 Period jitter: - ORB1	ORB1 roundtrip delay CCR — ATLAS versus outside temperature value (sensor values from the DIP)	Frequency value: BC1, BC2, BCREF absolute precision up to 1Hz, all synchronized with 10 MHz GPS(GMT)	ORB1, ORB2 period in BC counts, QPLLs from RF2TTC, Beam mode from BST, frequency registers from RFRX	Transmitter optical power value at: POINT4, CCR Receiver average frequency value at: CCR, ALICE, ATLAS, CMS, LHCb

System architecture

The heart of the system responsible for gathering measurement data consists of a **rack mount PC** (TTCpage1 server). The server has been equipped with two network adapters, one connected to the **CERN Technical Network (TN)** and the other one to the local TTCpage1 private network (PN).

The purpose of using PN is to ensure stability of data transmission between the server and the measurement devices (oscilloscopes, VMEbus crate controller and frequency meters). The location of the server within TN is imposed by a need for Data Interchange Protocol accessibility, which is unachievable within the **CERN General Public Network (GPN)**. The security has been also enhanced by configuring firewall with restrictive policies.

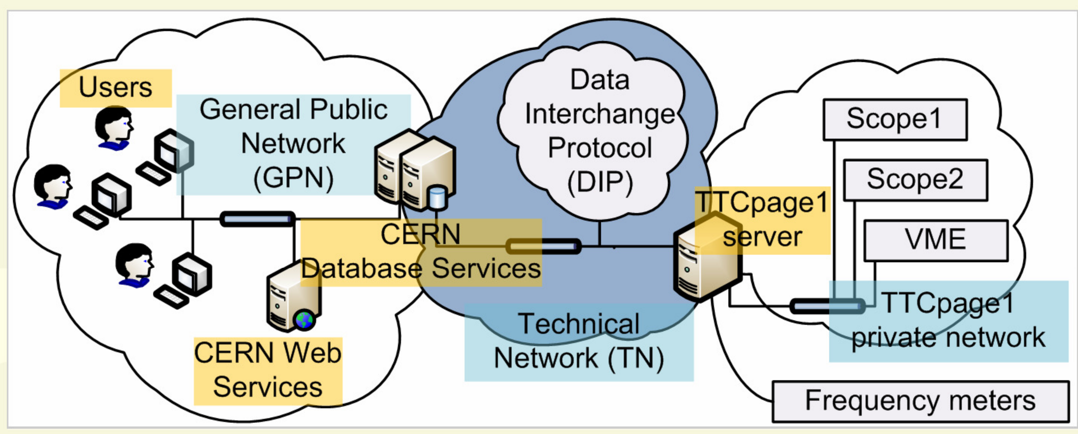

*Figure 4: **System architecture***

Once all the measurement data is gathered it is sent to a **database** provided by CERN database services. While this database is used for data storage it also acts as a "gateway" between the TN and GPN. An "emergency" copy of data is also saved on local TTCpage1 hard disk array. The array has been based on **RAID level 1** controller which provides simultaneous data write on two hard disk drives.

The system is mostly based on 10s interval which is equivalent to ~1GB data volume a year. The provided database service enables the system to store all the data during the whole LHC lifetime without the need for data reduction.

A **web server** provided by CERN Web Services is being used for **data visualization**. All of the webpage logic responsible for data reception from the database and graph plotting has been implemented in PHP and JpGraph library. The user interface has been based on AJAX technology provided by GWT (Google Web Toolkit) engine.

The webpage provides data visualization of the full range of monitored parameters and additionally supports the maintenance of the service itself, by analyzing e.g. sampling intervals, error flags and other.

Access to real time and post mortem data via a web page refreshed every 10s.

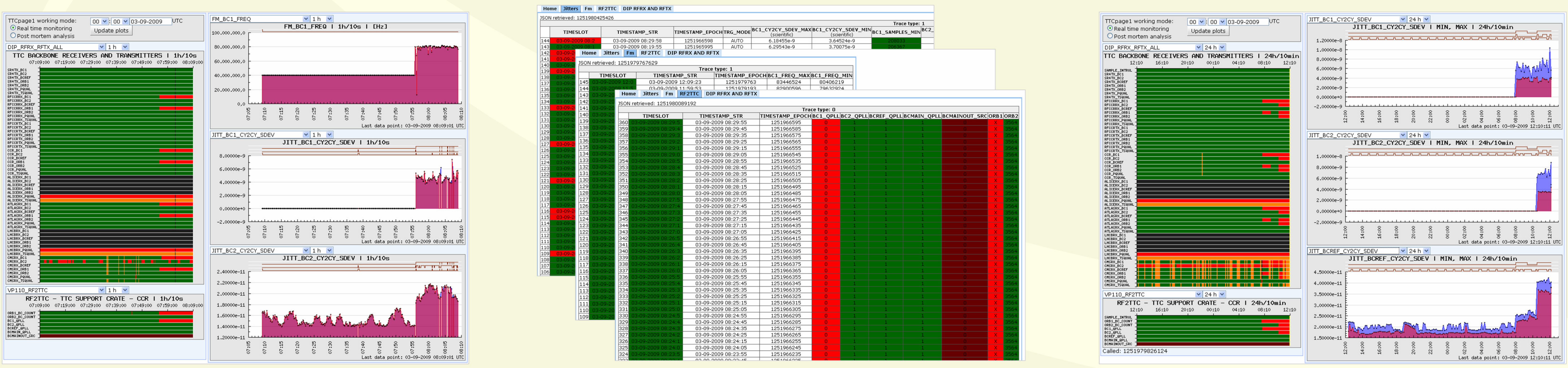

Figure 5: Web page screen shots — http://www.cern.ch/ttcpage1 (CERN NICE password authorization required)

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