AN OPERATIONAL EVENT ANNOUNCER FOR THE LHC CONTROL CENTRE USING SPEECH SYNTHESIS

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Abstract

The LHC Island of the CERN Control Centre is a busy working environment with many status displays and running software applications. An audible event announcer was developed in order to provide a simple and efficient method to notify the operations team of events occurring within the many subsystems of the accelerator. The LHC Announcer uses speech synthesis to report messages based upon data received from multiple sources. General accelerator information such as injections, beam energies and beam dumps are derived from data received from the LHC Timing System. Additionally, a software interface is provided that allows other surveillance processes to send messages to the Announcer using the standard control system middleware. Events are divided into categories which the user can enable or disable depending upon their interest. Use of the LHC Announcer is not limited to the Control Centre and is intended to be available to a wide audience, both inside and outside CERN. To accommodate this, it was designed to require no special software beyond a standard web browser. This paper describes the design of the LHC Announcer and how it is integrated into the LHC operational environment.

SYSTEM ARCHITECTURE

Announcements are generated on a dedicated server computer running Scientific Linux. The server generates announcement text based upon received data and translates the announcement into an audible message which can then be delivered to clients by a web server. In order to prevent disruption of the operational version of the Announcer, there are separate web servers for the CERN Control Centre and users not on the operational computer network. Figure 1 illustrates the processes involved to create an announcement and deliver it to a user's web browser.

ANNOUNCEMENT SOURCES

There are two sources of announcements at present: the LHC Timing System and software surveillance processes within the control system.

Announcements from the LHC Timing System

The LHC Timing System [1] is a good central source of information about both the current state of the LHC and new events that occur within the machine. As such, it was the first source of events used for the LHC Announcer. A timing receiver (CTRI) is installed in the LHC Announcer server, allowing the reception of timing

Table 1: Announcements from the LHC Timing System

Category	Events
Beam	○ Energy in 0.5 TeV increments ○ Fill numbers ○ Next injection ring, bucket and no. bunches ○ Injection ○ Beam dumps
Collimation	○ Collimators starting and stopping
Experiments	○ Beta* in 1m increments during squeeze
Feedback	○ Start dynamic changes
Instrumentation	○ Wire scans
Mode	○ Accelerator mode changes ○ Beam mode changes ○ Operational mode changes
Post-mortem	○ Global post-mortems
Power	○ Power converters start and abort ramps ○ 60A PC Permit changes ○ Sector Access changes
RF	○ Start and stop dampers

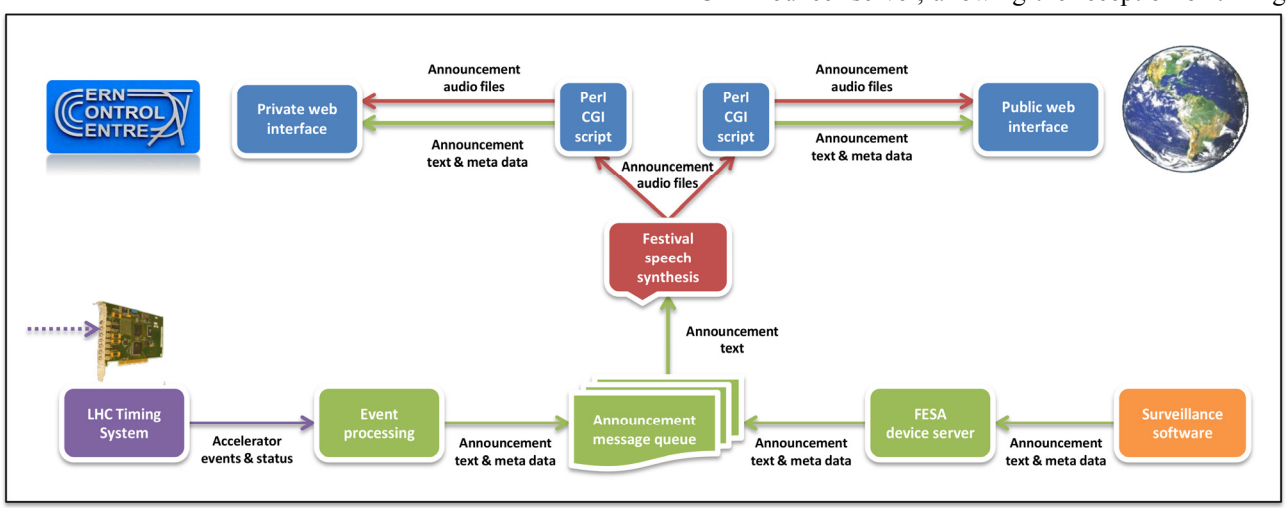

Figure 1: The LHC Announcer architecture.

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~/public_html>ls events
0_1317273215042118_power_Start power group, 123_.ogg
1_1317273504022752_mode_Beam mode, ramp down_.ogg
2_1317273505598175_beam_Fill number, 2169_.ogg
3_1317273879025657_power_Start power group, 123_.ogg
4_1317276201319233_mode_Beam mode, no beam_.ogg
5_1317279961198602_surveillance_At least one RF cavity, or low level, is down_.ogg
7_1317272524832764_power_60 amp PC permit, cleared for 4,5 and 5,6_.ogg
8_1317272810826116_rf_Stop dampers_.ogg
9_1317272812671035_mode_Beam mode, beam dump_.ogg
```

Figure 2: Example event files with meta data encoded within their names.

events. Each timing event may have a corresponding 16 bit payload, indicating a value associated with the event. Many events within the timing system are not suitable for direct mapping into announcements, so received events are processed by call-back code written in Perl. This allows announcements to be triggered on the arrival of a particular combination of timing events or when a timing event's payload changes by a given amount or passes a configured threshold. For example, the beam energy is received from the timing network at 10Hz. The event processing code will generate an announcement whenever the energy passes through a 0.5TeV boundary or if the energy stabilises at a particular value for more than 10 seconds. A deadband prevents repeated announcements.

Table 1 shows events that are currently announced using data received from the LHC Timing System and the categories to which they belong.

Announcements from Control System Surveillance Processes

After the LHC Announcer had been running for some time using only the LHC Timing System as a source, it became clear that it would be useful to allow other control system processes to make announcements. This was achieved by implementing a device server for the Announcer using the standard controls framework for the LHC (known as FESA) [2]. The LHC Announcer appears as a standard device within the control system, with a single property that triggers an announcement when set. This allows applications to communicate with the Announcer using the standard Controls Middleware (CMW) [3]. In order to limit who may trigger announcements, access to the controls device is protected by the Role-Based Access Control system (RBAC) [4].

Since messages announced by systems surveying the state of the LHC may potentially be sensitive, the FESA interface allows a flag to be set for each announcement to determine whether it should be sent to the publicly visible web server.

Details of the LHC Big Sister software that uses this mechanism to make announcements are given later in the paper.

SPEECH SYNTHESIS

Announcements from the Timing System or FESA server are added to a message queue in text form. A server process reads each message from the queue in turn and passes it to the Festival Speech Synthesis System [5] in order to generate the announcement audio. The audio is stored in an Ogg Vorbis file with the associated meta data (timestamp, category and message text) encoded within the name of the file as shown in Figure 2. Since a burst of events may occur at a faster rate than clients are able to play the audio, the 10 most recent events are stored at any time.

Several synthesised voices were tested when the LHC Announcer was originally developed, with the objective to find one which was both realistic and clear in its enunciation of the event messages. Finally a voice known as 'Nick' developed by the University of Edinburgh was chosen. The use of the synthesised voice required a non-commercial use agreement to be signed.

WEB INTERFACE

In order to make the LHC Announcer easily available to as wide an audience as possible, it was decided to use a web interface. As a result, only a standard web browser is required to run the LHC Announcer [6], rather than a dedicated application.

Features

The LHC Announcer web interface (shown in Figure 3) plays audio announcing any events that occur from the moment that the web page is opened. A rolling history of the last 20 received events is displayed at the bottom of the page, along with the time at which they occurred.

Categories of event (e.g. Beam, Collimation and RF) can be enabled or disabled, allowing the user to select the types of events that they wish to hear. A further option allows events from disabled categories to be included within the event history, in which case they will be shown greyed-out to distinguish them from events that were audibly announced.

A drop-down menu allows the user to add a Vistar fixed display to the web page, allowing the status of the LHC and the other elements of the accelerator chain upon which it depends to be shown visually in parallel to audio event announcements.

Implementation

The web interface uses Javascript to retrieve events and to update the event history and Vistar image (if displayed). When the web page is opened, the current

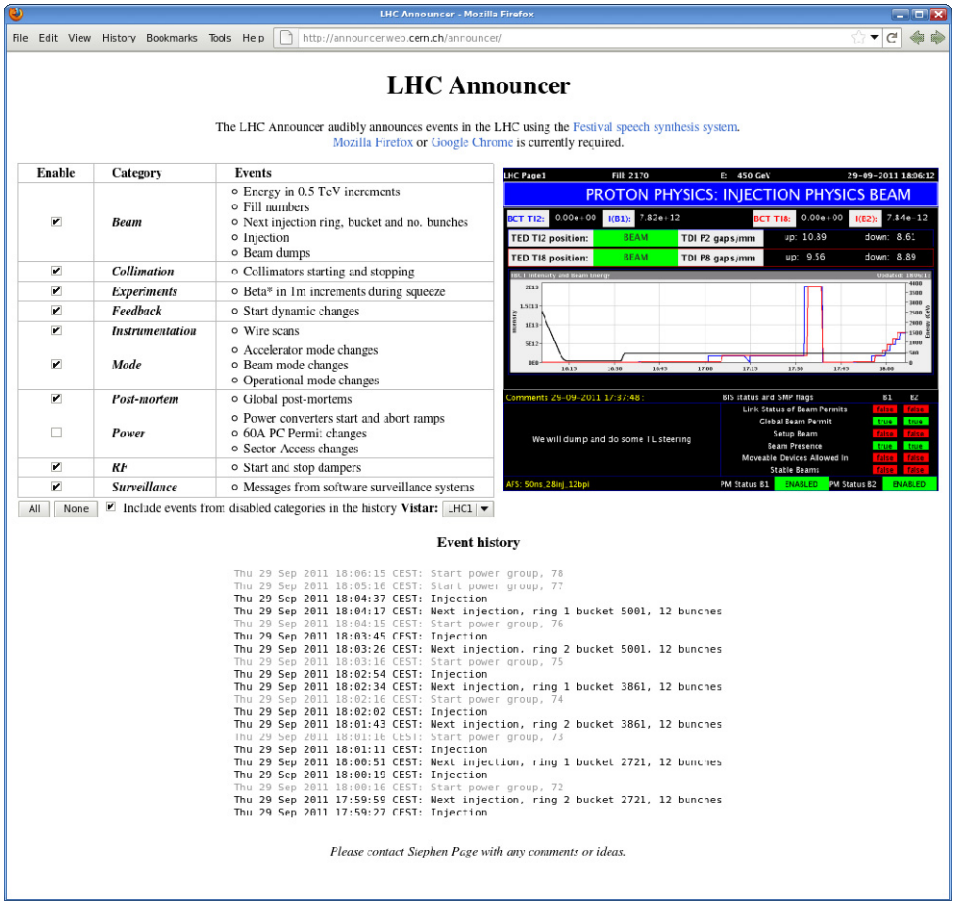

Figure 3: The LHC Announcer web interface.

UTC time is read from the client computer's local clock. That time is then passed in a call to a Perl CGI script which returns meta data for the next of the 10 known events that occurred after that time. The request for new event data is repeated periodically. When a new event is received by the browser, the timestamp of that event is passed with new requests, ensuring that all events are announced, even if a series of events occur faster than the corresponding audio can be played. On reception of meta data for a new event, the web page's Javascript determines whether to retrieve the Ogg Vorbis audio file from the web server and to update the event history based upon the options selected by the user.

This implementation works well when the number of active clients is reasonably low. For systems with a large number of clients, the periodic execution of the Perl CGI script used to retrieve data about new events could become a bottleneck. In this case, it may be more efficient to investigate technologies allowing new announcements to be 'pushed' from the web server, such as WebSockets (though browser support for these is rather immature) or so-called 'long polling'.

Web Browser Compatibility

The LHC Announcer uses relatively recent technologies that require explicit support by the web browser. The web page is written in standard HTML5, which is supported by the majority of modern browsers. However, the HTML5 Specification [7] does not dictate which audio codecs browsers must support for the *<audio>* tag, which the LHC Announcer uses for announcements. Unfortunately, there is no single compressed audio format that is currently supported by all of the most common web browsers, with most of them supporting either MP3 (which has commercial licensing and patent issues) or Ogg Vorbis (an open alternative). Ogg Vorbis is used for the LHC Announcer as it is supported by Mozilla Firefox, which is the most common multi-platform web browser in use at CERN and is also the only web browser available on all of the CERN Control Centre consoles. Google Chrome has also been found to work. Note that if it were important to support all HTML5-compliant browsers, then it would be possible to generate audio in multiple formats, though of course this would involve additional processing overhead.

SURVEILLANCE PROCESSES – THE LHC BIG SISTER

During 2011 a new monitoring infrastructure called Big Sister was put in place for the LHC based upon the architecture of the Software Interlock System [8].

Through a rather complex logic which correlates information from different accelerator systems, the LHC Big Sister can anticipate failures, providing operators with enough warning time and preventing the beams from being dumped, allowing more efficient operation of the LHC.

The logic trees are very flexible and quickly configurable. They can be associated with a measurement of a condition, a device state or property, beam mode, beam quality. The measured parameter is compared to a reference value, with the outcome that the measurement either matches the desired value (condition is true) or not (condition is false). Each of these basic building blocks is associated to one piece of accelerator equipment and they can be combined to produce a more elaborated logical condition. The top-level condition can be either true or false depending on the condition of the elementary building blocks via logic ANDs, ORs or NOTs.

As many alarms and warnings in the LHC Control Room provide visual information, there is always the risk that the operator overlooks some of those alarms or warnings because of a saturation of visual information. Since the LHC Big Sister tries to catch situations that will, in a short while, result in a beam dump, giving the warning messages visually was discarded as an option because failing to react to a warning may result in the loss of the LHC beams. Therefore, the LHC Announcer was chosen as the communication mechanism from Big Sister to the operations team. In this way, the operator does not need to actively seek the information, rather the information comes to him in the form of an audible message. Many beam dumps have been avoided thanks to the combined action of Big Sister and LHC Announcer.

When a condition monitored by Big Sister is false, the associated message is exported to the LHC Announcer which then reports the message and warns the operators about faulty equipment or a forgotten action. The shift crew reacts to the warning, fixing the problem and avoiding a potential dump of the beams. For example, one of the logic trees monitors the status of the Radio Frequency Cavities of LHC. If two or more cavities enter into a faulty state the beams will be dumped. The Big Sister continuously monitors the status of the cavities and as soon one of them enters a faulty state it is announced via the LHC Announcer. Consequently, the operator switches it back on and operation proceeds. Of course, there is also a visual alarm if a cavity becomes faulty, but it has been overlooked on several occasions Since the message has been reported by the Announcer, this type of fault has always been corrected without loss of the beams

LHC ANNOUNCER USAGE

The LHC Announcer has proved useful to a number of different types of user. Its main purpose is to inform operators within the CERN Control Centre of events occurring in the LHC, which may require their attention. Additionally, some equipment experts use the Announcer in order to be informed of events that may relate to tests that they are performing.

The public version of the LHC Announcer web interface has also been popular with people around the world who are interested in the operation of the LHC. As such, it also makes a useful contribution to the publication of CERN's activities and the fostering of public interest.

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