Monitoring the Chandra X-ray Observatory via the Wireless Internet

Bradley D. Spitzbart, Scott J. Wolk, Robert A. Cameron

Chandra X-ray Center, Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138

Abstract. The *Chandra X-ray Observatory*, launched in July 1999, continues to provide unprecedented high energy astrophysical discoveries with efficiency and reliability. From time to time, though, urgent operational decisions must be made by engineers, instrument teams, and scientists, often on short notice and at odd hours. There are several real-time, mostly Internet-based data resources available to aid in the decision-making discussions when a crisis arises. *Chandra's* Science Operations Team (SOT) has been experimenting with emerging Wireless Application Protocol (WAP) technologies to create yet another pathway for data flow. Our WAP Internet pages provide anytime, anywhere access to critical spacecraft information through cellular phones or other WAP-enabled devices. There are, of course, many challenges in attempting to present useful, meaningful content on a 5 $\times$ 12 character screen over limited bandwidth in a way that is user-friendly and beneficial. This paper will discuss our experience with this developing and promising new medium, design strategies, and future enhancements.

1. Introduction

The *Chandra* wireless web pages were conceived and have evolved to provide ready access to the most relevant spacecraft information at critical, decision-making times. In its first incarnation, data were requested and passed through two-way pagers. Here we describe our next generation approach of using Wireless Application Protocol (WAP)-enabled devices and Wireless Markup Language (WML) for a more comprehensive and accessible application. At present the pages are customized for viewing on cell phones. These same devices are also capable of acting as pagers through text messaging and in fact most of the team uses the phone to its full, versatile convenience for voice, text, and web browsing. E-mails are sent directly to the devices by SOT monitoring software, alerting to high radiation conditions, and other spacecraft or system anomalies. As with any emerging technology, the learning curve is quite steep, but we have solved several technical and design issues along the way. The URL for the SOT wireless home is `http://cxc.harvard.edu/mta/WL/sot.wml`.

Figure 1. [left to right] The *Chandra* Snapshot main page, CCDM subsystem snapshot, support schedule, and observing schedule.

2. Content and Design

The wireless pages are essentially WML mirrors of the most mission-critical of our myriad standard web pages[1]. Examples of these pages are shown in Figure 1 and described below. By emphasizing a simple, server-side approach, we are able to create and maintain our wireless web quickly and efficiently. Performance has been more than satisfactory as we utilize the server for computations and pass only small amounts ($<$ 2Kbytes) of data at a time.

Several design issues had to be considered to map full HTML pages to WML. For instance, most devices are limited to only about 12 characters across and 5 characters down each screen. To compensate, many mnemonics are shortened, long pages are broken into multiple pages, and navigation links are positioned atop and occasionally throughout long pages. To counter the color and font non-capability we provide separate pages for a reference to each colored mnemonic (see section 2.1.). Most devices also attempt to efficiently cache and redisplay previously called pages. To prevent this action, an always-expired header is added so that the most current data are displayed on each invocation during real-time contacts. Finally, the wide variety of device types and manufacturers make on-line emulators [2] invaluable for testing as well as for saving air time charges.

2.1. Chandra Snapshot

Our main real-time web page is the *Chandra* Snapshot. This page is created by reading the *Chandra* telemetry stream through a C++ based decommutator, then formatting the HTML output with PERL scripts. State checking occurs in the PERL code and values are color coded on the web to indicate any limit violations. To implement the WML version of the Snapshot, we simply added a module to output a plain text log of telemetry values. The WAP pages then run an underlying PERL (CGI) code to extract and format the user requested data. An example of the output WML code is given in Figure 2. The CGI is also used to handle "browser" buttons which make data available from the past three days. The color coding of the original pages is preserved in the black and white only WAP pages by displaying separate pages for each color. That is, the "RED Flags" link shows all values that are colored red indicating a limit violation or unexpected state.

---

[1] `http://cxc.harvard.edu/mta/sot.html`

[2] http://www.gelon.net has one; there are many others.

```
Expires: Mon, 01 Jan 1980 05:00:00 GMT
Date: Mon, 01 Jan 1980 06:00:00 GMT
Content–Type: text/vnd.wap.wml
<?xml version='1.0'?>
<!DOCTYPE wml PUBLIC '–//WAPFORUM//DTD WML 1.1//EN'
 'http://www.wapforum.org/DTD/wml_1.1.xml'>
<wml> <card id='index'> <p>
UTC 2002:282:20:31:23 (Oct 9) <br/>
OBT 2002:282:20:30:58 <br/>
OBT      150582658.60 <br/>
CTUVCDU  6530254 <br/> ONLVCDU  6530240 <br/>
OBC s/w NRML <br/> OBC Errs   0 <br/>
FMT2_EPS  <br/>
<i>CPEstat NORM </i><br/>
OBSID  61005 <br/>
SCS 128   ACT <br/>
SCS 129   ACT <br/>
<u>SCS 130  INAC </u><br/>
SCS 107  INAC <br/>
UpL CmdAcc  53775 <br/>
Cmd Rej A       64 <br/> <br/>
<a href="snap.cgi?dat=Snap_dat/sccdm.0">Earliest</a><br/>
<a href="snap.cgi?dat=Snap_dat/sccdm.1486">Previous</a><br/>
<a href="snap.cgi?dat=Snap_dat/sccdm.1488">Next</a><br/>
<a href="snap.cgi?dat=Snap_dat/sccdm">Latest</a><br/>
Current i: 1487 of 1577<br/> Goto i:
<input type='text' name='indx' value='1487' size='4' format='*N'/>
<a href="snap.cgi?dat=Snap_dat/sccdm.$(indx)">GO</a><br/> <br/>
<a href="snap.wml">Index</a><br/>
<a href="snap.cgi?dat=Snap_dat/snap_curr">Current</a><br/>
<a href="http://cxc.harvard.edu/mta/WL/sot.wml">SOT Home</a><br/>
<br/>(Snap_dat/sccdm 1487)<br/>
</p></card> </wml>
```

Force reload on each invocation.
Most devices will default to cached page otherwise.

WML header/card identification

Data Section

Note <i> tag to mark "stale" and <u> tag to mark "yellow" conditions, although most devices can not yet display such characters.

Archive browser links/information

SOT Wireless links and WML endtags

Figure 2. Example WML code of SOT wireless Snapshot. This is output from a CGI script and displays the CCDM subsystem mnemonics.

2.2. Radiation Monitoring

The radiation environment in which *Chandra* operates is closely monitored. During times of elevated solar activity it is often necessary to consider stopping observations in order to protect the science instruments. We provide renderings of Advanced Composition Explorer (ACE) spacecraft data and Chandra Radiation Model (CRM) predictions along with the current spacecraft configuration and ephemeris to aid in these decisions. These pages are autonomously updated every five minutes and are available as static WML pages.

2.3. On-line Schedules

When crises arise it is often helpful to have ready access to various schedules. The *Chandra* wireless web provides links to the spacecraft support schedule. This lists the times of our thrice daily, one-hour contacts for the past day and the next two days, with the current or next pass highlighted for easy reference. This page is autonomously updated every ten minutes. We also create a simplified version of the observing schedule to assist when replan decisions must be made. The main page gives links to a daily listing of observations for the current week and the next scheduled week. The start time, observation id, target name, instrument, and grating parameters are listed for each observation. These pages are updated manually upon the approval of each weekly schedule.

3. Conclusions and Future Work

Wireless Internet technology will continue to advance with more bandwidth, larger displays, greater graphical capability, and code standardization being made available incrementally. This will allow us to offer more *Chandra* systems and scientific data quickly and conveniently via wireless devices.

Some of our short and long term visions include the following:

- Make more text-only pages accessible.
- Explore adding some simple graphical representations (ACE data, for instance) in the near future.
- Expanded graphical services as we convert our many monitoring and trending plots for wireless access.
- Enhanced user interactivity for searching and requesting specific data values and timeframes for trending and analysis.
- Supply products appropriate to a wide variety of devices. Compatibility and translation issues will be investigated to implement our wireless web on upgraded cell phones, PDAs and other devices.

While relatively quick and easy to implement and maintain, the wireless web has proven to be a valuable resource for *Chandra* Operations and will continue to evolve and expand.

Acknowledgments. We acknowledge valuable user feedback and bug reports. This work is supported by the *Chandra X-ray Center* under NASA contract NAS8-39073.

References

Wolk, S., Spitzbart, B., & Isobe, T. 2003, this volume, [P6.10]

Frost, M., "Learning WML & WMLScript", O'Reilly, 2000.