Telescience: a personal view

Tony van Eyken, 13 March, 1994.

Introduction

Telescience means many different things to different people. Perhaps it is true to say that what is generally considered to be required for telescience is not too close to what would actually be used. However, a telescience capability is seen as a desirable future feature of the EISCAT Svalbard Radar and we should try to define just what is required. In addition, the construction of such a facility represents, in my opinion, a very appropriate project to be undertaken by groups outside the EISCAT organisation itself.

Does the way we currently perform experiments represent a good model for telescience?

If one considers how experiments are conducted at EISCAT, for example, the various data displays are generally ignored for most of the time. The engineering staff listen only for the alarm bell (together with making some routine logging maybe once an hour) and scientists often miss important indicators (if you don't believe that, consider how long it takes to detect a fault which does not cause the alarm bell to ring). When a fault has been detected, it is not often that it can be identified using the standard data displays. The existing displays are visually attractive, but are not sufficiently interesting to hold anyone's attention for very long.

I have the impression that people imagine the telescience environment to involve sitting in front of some graphical display of the real-time data waiting for exciting events to occur, at which times one would decide how to change the programs, etc.. However, philosophically correct science is not done like that; butterfly collecting is, but not science.

Clearly, then, the way we perform experiments right now is not a good model and reproducing the rtgraph and the real-time colour analysis output remotely is not going to be appropriate for effective telescience - though it may be fine, or even essential, for public relations purposes. Such displays are pretty but they don't encourage effective monitoring. If we want effective monitoring, we must have the computers do it, humans are not well adapted to such tasks, computers are.

A better model for the telescience requirement might be to consider how a user sets up a new experiment, particularly perhaps how someone at one EISCAT site sets up another site to perform an experiment, and checks that it does it correctly. Additionally we might consider how EISCAT staff, using dial up modems and fairly dumb terminals, go about finding faults remotely.

The playing field

So what can be said about telescience requirements? (Here, I don't see a real difference between what one would like to have for the ESR and what one would like to have for the existing EISCAT.)

One can perhaps consider the requirement under four headings:

1.1 Tools to support experiment design and testing

Here, rapid response is not as important as detailed information about the system and how it performs. One needs a mechanism to launch a task, anything from loading a memory location to starting a complete experiment, and a matching mechanism to see if the systems performed as one expected. Maybe a combination of text and graphical displays of state variables and data structures is enough?

1.2 Tools to support experiment monitoring

The facility which would actually be used is a single logical entity which showed the lack of an error state; a simple heart-beat monitor would be enough. Of course, one clearly needs the colour displays, etc. also, but very fast response is not essential. In addition, a mechanism to transfer the resulting data to the user is required, but, again, this is not time critical.

The system should also allow users to inspect and, where appropriate, retrieve data from related experiments, both at the same site and elsewhere. Where necessary, special programme experimenters must be able to control access to their own real-time data.

There is also an important requirement exemplified by rocket co-ordinations, where detailed real-time data are required at a remote site. In the longer term, this requirement may well be met using the approach suggested below, but I will release a further discussion document on shorter term solutions to cover these cases.

1.3 Tools to support real-time error location and correction

The heart-beat at 1.2 has gone, what do we need to find out why? Well, we probably need the same mixture of graphics and text that we needed at 1.1.

1.4 Tools to provide hardware monitoring/maintenance planning, etc.

We assume that everything associated with the physical safety of the hardware is taken care of locally by means of hardware and/or software interlocks. Beyond this, a heart-beat monitor is again the practically useful facility, backed up be access to system parameters and logs. Again, there is no time-critical component, we just need to be able to determine what course of action needs to be followed to correct a fault condition and apply appropriate resources. To this one might also add two further categories:

1.5 Tools to support remote control of experiments

I assume that 1.1/1.2 provide a means to schedule an experiment start/end, so here we consider more direct interaction with the system. Experience has shown that if one requires to rapidly change experiments based on data recorded, one had better program the computers to monitor for the required conditions because people are too slow, easily distracted and make mistakes in the heat of the moment (I recall occasions when the process of changing modes has been fumbled such that no observations at all were made during the required event). Beyond this, the usual scheduling of experiment start/end is probably enough to allow a remote campaign to be conducted effectively.

However, a secure mechanism must be implemented to ensure that the correct user has undisturbed control of the system, while retaining the possibility for watch staff to assist where necessary.

1.6 Tools to support remote engineering control

Here I am thinking of control tasks such as cold-starting the transmitter, unstowing the antenna and starting the air-warning radar. For these, a really secure command system is essential. Since the number of possible actions is limited, and can be defined in advance, we could arrange that the user-interface would be based on the typical window concept with pull-down/pop-up menus, push buttons, sliders, etc. (this is largely the case for 1.5 as well, particularly if one consideres that really unusual programmes will probably require scientists to visit the physical facility anyway). Likewise, the returned monitoring parameters can be readily displayed using windowed concepts, with both text and graphics displays being possible and useful.

One must also consider some practical requirements:

- 2.1 The equipment required must not be so expensive or unusual that it cannot be either afforded or effectively supported. In practice we should probably plan to support UNIX, MS-Windows and Macintosh environments; perhaps we should plan to provide an effective baseline system when running on a typical 486 PC?
- 2.2 The communications between the host and the telescience terminal must normally use the public Internet. This means that we cannot support time critical requirements - a conclusion which applies even if we would have permanently leased, private circuits. Also, we should minimise the traffic across the network by transferring data (or change-data) only and providing all display drivers, etc. at the telescience terminal end.
- 2.3 There may be multiple passive telescience users, but controllers must enjoy protected access to the system. This means we will need some sort of user validation, and probably also encrypted command transfers.

2.4 A remote user must be able to monitor the system effectively without the benefit of a detailed knowledge of what the physical systems look like. We can use all sorts of short cuts to identify problems remotely, but only because we have an intimate knowledge of the hardware, software and computer systems involved. In the brave new world of telescience, that can no longer be assumed. This may mean that all the manuals should be available on-line and in a form which can be easily searched (it also implies that full documentation must actually exist).

And some philosophical matters:

- 3.1 The system should, as far as possible, use standard technologies and paradigms.
- 3.2 It should be as public and unrestricted as possible commensurate with the safe operation of the radar.
- 3.3 If we have remote control of the major hardware, such control systems must be implemented to be unconditionally fail-safe. This is life critical stuff.
- 3.4 We must expect to be attacked by unfriendly crackers.
- 3.5 We probably need these facilities far earlier than anyone imagines.

So what?

To my mind, none of this seems very difficult, or even contentious. However, it does represent a very great deal of careful software design, construction, testing, testing and more testing. I believe that the effort required is considerably more than we can spare.

What can be done? The only effective solution, also the logical and sensible one, is to build on top of the work of others. A potential candidate is to use the approach represented by the World Wide Web (WWW)/Mosaic. Can this provide what we want, or can it be easily extended to cover our needs?

NCSA Mosaic

Mosaic is a distributed hypermedia system designed for information discovery and retrieval over the global Internet. It is a product of the National Center for Supercomputing Applications in the USA and is available, free for UNIX, MS-Windows and Macintosh systems.

A corresponding server is used to make data products available. It provides various levels of security both by conventional name/password and by transparent restrictions based on ip addresses.

The system is extensively documented, and the source code is readily available (see next paragraph). All sorts of data products can be distributed, including images in various forms, text, PostScript, sound, movies, etc. and Mosaic clients automatically spawn appropriate viewers on receipt of recognised data types. Documents can be distributed in hypertext style making documentation both easy and effective, but with the added feature that hypertext pointers are not restricted to particular files, machines or even continents. Mosaic clients support the submission of queries (including support for fill-out forms), and queries can initiate arbitrary scripts on the server machine

The Mosaic system, and the underlying WWW and hyperlink system seem to be very well thought out, implemented and supported.

A development server system has been operational at EISCAT since early December 1993 and investigations continue into the use of this approach for telescience purposes. If you have not already done so, you can obtain a Mosaic client by anonymous ftp from ftp.ncsa.uiuc.edu in the directory Mosaic; you can access the EISCAT system by loading URL (Universal Resource Locator) http://seldon.eiscat.no/homepage.html once you have the Mosaic client running.

We have been setting up pathways to allow Mosaic users to access various sorts of information about EISCAT, including schedules, operational information (even including the infamous White Board), and large parts of the Common Programme analysed data sets (including all of 1993 and 1994). There are also links to other services, including Millstone Hill, UNIS (notably the magnetometer in Longyearbyen), Leicester University (for SABRE plots), the entire Freja archive, etc... URSIGRAMS are posted automatically on arrival.

In addition Mosaic users already have immediate access to the state of the real-time data acquisition systems in Tromsø and I expect to make rtgraph plots and transmitter logging information available within a few days.

Can Mosiac fill our needs?

Based on our investigations and trials I think we can say that this approach can provide us with what we require, but that we will need to develop one or two specialised facilities for our particular needs.

I believe that tasks in this area represent a good opportunity for development by groups in the Associate countries. Some specific tasks would be:

Development of extended server/client models which can support the transfer of partial data sets. For example, if one wishes to monitor the real-time colour plots of analysed data, one does not wish to transfer the whole plot every time, but only the new information added since the last access.

Implementation of 'heartbeats' and associated interlocks.

Graphics design of input and output screens.

Investigation and implementation of major data compression schemes to allow transfer of entire data structures where necessary.

Encryption/decryption of commands and clean provisions to allow control by a specified individual or group.

Design of display tools. For example, the construction of IDL or MATLAB scripts to display data in particular styles.

Such extensions would ideally be constructed in conjunction with NCSA, and may find wide use beyond the immediate EISCAT community.

Conclusion

At the present time, NCSA Mosaic/WWW seems to offer the possibility of providing telescience capabilities which can meet our requirements. With enhancements which seem possible to accomplish within reasonable time scales, we might expect to be able to support a wide range of operations entirely remotely.

I therefore intend to develop further both the existing Mosaic exercise and the requirement for forther developments.

Inputs to either or both of these exercises will be very welcome.

· DATABASES

- · MONITORS
- · 'REALTIME' CONTROL
- · POST ANALYSIS

REQUIREMENTS

Experiment design and testing. Ι,

2. Experiment maritoring.

"Real-time" error identification and correction 3.

4. Hardware manitoring.

Remote control. 5.

7.

6. Remote engriseering cartrol.

CONSTRAINTS

1. Affordable

2. Communications layer

3. User validation

4. Documentation

5.

GENERAL CONSIDERATIONS

1. Standard technology/methods

2. Public/unrestricted access

3. Fail-safe

4. Crackers/Hackers

Time scales 5.

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The EISCAT Scientific Association

The <u>EISCAT Scientific Association</u> is an international research organisation operating two **incoherent scatter radar** systems, at <u>UHF</u> (931 MHz) and <u>VHF</u> (224 MHz), in Northern Scandinavia.

It is funded and operated by the research councils of Norway, Sweden, Finland, France, the United Kingdom and Germany.

EISCAT (European Incoherent Scatter) studies the interaction between the Sun and the Earth as revealed by disturbances in the <u>magnetosphere</u> and the ionised parts of the <u>atmosphere</u>. The radars are operated in both Common and Special Programme <u>modes</u>, depending on the particular research objective, and Special Programme time is accounted and distributed between the Associates according to <u>rules</u> which are published from time to time.

The EISCAT transmitter site is located close to the city of <u>Tromsø</u>, in <u>Norway</u>, and additional receiver stations are located in Sodankyla, Finland, and Kiruna, Sweden. The <u>EISCAT</u> <u>Headquarters</u> are also located in Kiruna. Several other Incoherent Scatter <u>facilities</u> are distributed about the World. There is an elegant introduction to the facilities of our friends at the <u>Millstone Hill Observatory</u>.

Incoherent Scatter Radar requires sophisticated <u>technology</u> and EISCAT engineers are constantly involved in <u>upgrading</u> the systems.

The EISCAT Scientific Association is currently constructing a new incoherent scatter radar facility, the **EISCAT Svalbard Radar**, near Longyearbyen, on the island of Spitsbergen, far to the North of the Norwegian mainland.

In addition to the incoherent scatter radars, EISCAT also operates an <u>Ionospheric Heater</u> at Ramfjordmoen to support various active plasma physics experiments in the high latitude ionosphere.

Further Reading

All sorts of operational information, including colour data plots, is available as shown in the index. More material will be added as time allows.

A collection of useful pointers to other documents is available in <u>Appendix One</u> while <u>Appendix</u> <u>Two</u> contains pointers to documents of interest to those constructing httpd services.

Further information about EISCAT can be obtained from:

Tony van Eyken.

This is an experimental Mosaic Service. It is currently under development and may well not work as expected. In particular, EISCAT accepts no responsibility for the consequences of the use of any data obtained through this service. Please see also the <u>copyright</u> notice.

The style and opinions expressed or implied in these documents are entirely \underline{my} own and do not necessarily represent the views of the EISCAT Scientific Association. As time progresses more features may be added to this service and suggestions for improvements to the structure or contents are most welcome :-)

For your information, here is a page showing the use of this service to date.



The Good Stuff....

What we will do, 'The Future': Schedules, etc.....

- Latest available EISCAT schedule.
- Incoherent Scatter Coordinated Observation Days for 1994.

What we are doing now, 'The Present': Monitors, etc.....

- Current status of the data transfer at Tromsø.
- The latest available rtgraph (Tromsø, UHF).
- Current contents of the ESR radar controller memory at Tromsø.
- The latest available **ionograms** recorded by the Dynasonde at Ramfjordmoen.
- The White **Board**.

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- An example transmitter log.
- Try the trial version of the **EROS manual** as a prototype for future documentation.

What others are doing: Predictions, other data sources, etc.....

- Latest **geomagnetic**, **solar** and **auroral** reports (These might take a while at busy times since each launches a script to obtain the very latest available material).
- The Meudon **URSIGRAMS**.
- Information available at the Andøya Rocket Range.
- Information about the <u>Millstone Hill Observatory</u>, including the IS radar <u>schedules</u>, and the National Astronomy and Ionosphere Center <u>Arecibo</u> Observatory.
- <u>Various services</u> from the Ionospheric Physics Group at the University of Leicester, notably SABRE data.
- <u>Geophysical data</u> from the University of Tromsø, including <u>magnetometer</u> data from Tromsø (the data are available as .gif files, updated every 12 minutes). Tabulated one minute data, as well as data

from five other sites, are also **available**. Note the **rules of the road** for the use of these data.

- Look <u>here</u> for magnetometer data from the UNIS instrument in Adventdalen (the data are available as .gif files, updated every 12 minutes).
- The Rutherford Appleton Laboratory EISCAT group have a WWW server at <u>**RAL**</u>.
- Check out the WWW server at the <u>Center for Atmospheric and Space</u> <u>Science</u>

What we did, 'The Past': Data archives, etc.....



The World Day Common Programme data should be accessible to everyone. These data are the property of the EISCAT Scientific Association and the usual 'rules of the road' apply to their use. In order to implement the provisions of EISCAT's statutes controlling the distribution of data, the **full data set** can only be accessed by those within the EISCAT Associate Countries. Please contact **Tony van Eyken** if you need advice on what constitutes a proper use of this resource, or if you need access to the restricted area. Note that these colour plots are encoded using PostScript Level 2; in addition, many of them have a blank character as the first character on each line. Neither of these attributes causes any problem with the latest version of GhostView/Script, so please consider upgrading if you have troubles displaying these data.

• The latest batch of Common Programme analysis **notes** as recently dispatched to Associate's Data Representatives.

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 The full EISCAT Freja dataset, processed using GUP, is available to registered users at the ftp site in Uppsala; please contact

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Hermann Opgenoorth if you wish to be added to the list of users.

A mail reflector is used by the EISCAT users to discuss matters of common interest. Anything mailed to discuss@eiscat.no will reach everyone who has asked to be included in the distribution list – send an email to tony@eiscat.no if you want to join in too.



EISCAT Tromsø UHF and VHF Radars Real Time Status

09:19:00 Mon, Feb 21 (local time)

UHF DMA transfer

• Timeout

VHF DMA transfer

• Recording

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- o Experiment : cp-7-f-2ms-v
- o Dump Time : 94 02 21 08 16 40 UT
- o Pre Integration Time : 10 s

o West Side Antenna – Elevation angle : 90.0 deg – Phase Angle : 0.50 deg

- o East Side Antenna Elevation Angle : 90.0 deg Phase Angle : 0.50 deg
- o Receiver Settings :

Signal Path : ALL X

Signal Path Attenuator : X : 12 Y : 63

СН	F	LO2 (MHz)	Filter Type	Bandwith (kHz)	ATTN (dB)	Sampling Rate (us)
1 2						
3 4 5	F8	40.0	Butterworth	20.0	20	15.0
6 7	F7	40.2	Butterworth	20.0	20	15.0
8	F6	40.4	Butterworth	20.0	20	15.0
o Powe	r Klystron	A: 101.0 kW				
o Power Klystron B: 89.0 kW						
o Hi Vo	ltage Klys	tron A: 83.0 kV				

o Peak Power Klystron A: 1.03 MW

- o Peak Power Klystron B: 1.07 MW
- o Scancount: 536

Further information about this service can be obtained by mail to Patrick Guio.



1. EROS COMMANDS in EROS Version 93

This is an internally linked document with subject and alphabetical indexes.

Note that you can also use File-Find_in_current to locate particular commands.

All EROS-commands currently available are listed below. For each command the required parameters are given together with a short description of what the command does. The commands are ordered alphabetically within logical groups. All commands are given either from the local command terminal at which the EROS system was started, from the command terminal at one of the two other sites (here referred to as "remote"), or from the compiled version of the ELAN file. Some of the commands are restricted to the local command terminal or the ELAN files only. This is mentioned in the explanation. All parts of a command may be abbreviated as long as they are unambiguous.

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1.1. GENERAL SYNTAX

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General syntax of the commands is:

<COND> <REMOTE> <SYSTEM>--<COMMAND> <PARAMETERS> %<COMMENTS>

All parts (except <COMMAND>) are optional or have default values. They are separated by at least one space. Leading spaces are ignored.

- <COND> := &<S> where <S> := T, K, S, or R for K and S. Conditional compilation: this statement will be compiled only at the specified site(s). Only allowed in ELAN-file.
- <REMOTE> := REMOTE(<SITE>) The command is directed to the other site(s).
- <SITE> := K, T, S, R, A, NK, NT, NS where R = the other two sites, A = all, NK = Not Kiruna, NT = Not Tromsø, NS = Not Sodankylä
- <SYSTEM> := UHF or VHF or abbreviations. Default is UHF that may be changed to VHF (see <u>DEFAULT-SYSTEM</u>).
- Note, a hyphen, not a space should be given between <SYSTEM> and <COMMAND>.
- <COMMAND> := as specified below.
- <PARAMETERS> := <PARAMETER 1> <PARAMETER 2>,.., <PARAMETER N> If a command needs parameters and they are not specified appropriate prompts are given. Two successive commas in the parameter list result in the default value being used.
- <COMMENTS> := any text as long as it fits on one line.

Example:

&T REM(R) RUN-EXPERIMENT CP-1-J-R,110,0,0 % schedule exp

Means in a Tromsø ELAN-file the program CP-1-J-R is started in Kiruna and Sodankylä the



EISCAT Scientific Association

Server 1 HTTPD Statistics

09:20:41 Tue, Mar 1

Since the start of this service, a total of 10457 accesses have been made from 379 machines.

There were:

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- 1008 accesses from 62 machines in December 1993,
- 4358 accesses from 196 machines in January 1994,
- 5030 accesses from 182 machines in February and
- 61 accesses from 4 machines in March.