The Future WMO Information System

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February 2004

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Executive Summary

In 1998, it became apparent that the various WMO Programmes either had already or were in the process of developing their own information systems independently of each other. Since the multiplicity of systems resulted in incompatibilities, inefficiencies, duplication of effort and higher overall costs for Members, the continued development of the systems in this uncoordinated manner would have exacerbated these problems and would have further isolated the WMO Programmes from each other and from the wider environmental community. It would have increased the difficulty in sharing information between programmes, which was essential for them to fulfil their requirements. During its fourteenth session in 2003, 5 to 24 May 2003, the World Meteorological Congress reviewed a preliminary concept proposed by CBS and confirmed that an overarching approach was required: a single coordinated global infrastructure, the Future WMO Information System (FWIS):

- FWIS would be used for the collection and sharing of information for all WMO and related international programmes.
- FWIS would provide a flexible and extensible structure that would allow the participating centres to enhance their capabilities as their national and international responsibilities grew.
- Implementation of FWIS should build upon the most successful components of existing WMO information systems in an evolutionary process.
- FWIS development should pay special attention to a smooth and coordinated transition.
- The basis for the core communication network would be the present communication links used within the World Weather Watch (WWW) for the high priority real-time data.
- FWIS should utilize international industry standards for protocols, hardware and software.

FWIS is intended to serve all relevant WMO programmes. It would bring savings to the meteorological/hydrological community as a whole and increase the efficiency of their operations.
Reviewing the requirements of the different WMO programmes, the following needs were highlighted:

- A widely available and electronic (on-line) catalogue of all meteorological and related data for exchange to support WMO Programmes is required.
- It should be possible to rapidly integrate real-time and non-real-time (archive) data sets to better interpret weather events in a climatological context.
- There is a need to identify and utilise the potential of data from observation sites established by one Programme to meet the requirements of other Programmes.
- There is a need to harmonise data formats, transmission standards, archiving and distribution mechanisms to better support inter-disciplinary use of data and products.
- Standard practices for the collection, electronic archival and exchange of metadata, both high-level and detailed, especially for stations and instruments, are needed.

In more technical detail, FWIS should provide an integrated approach to meeting the requirements of:

- Routine collection and automated dissemination of observed data and products ("push");
- Timely delivery of data and products (appropriate to requirements);
- Ad-hoc requests for data and products ("pull").

In addition, FWIS should be:

- Reliable
- Cost effective and affordable for developing as well as developed Members
- Technologically sustainable and appropriate to local expertise
- Modular and scalable
- Flexible and extensible - able to adjust to changing requirements and allow dissemination of products from diverse data sources and allow participants to collaborate at levels appropriate to their responsibilities and budgetary resources

FWIS should also support:

- Different user groups and access policies, such as WMO Resolutions 40/25
- Data as well as network security
- Integration of diverse datasets

Taking into account that information systems technology is evolving rapidly, FWIS should utilize industry standards for protocols, hardware and software. Use of these standards will reduce costs and allow exploitation of modern communication services, including the ubiquitous Internet and web services. The ultimate implementation of FWIS will build upon the most successful components of existing WMO information systems. It will continue to rely upon the WMO communication system (initially the GTS) to provide highly reliable delivery of time-critical data and products. However, the following new features will be added:

- Common to all WMO programmes, therefore supporting variety of data types
- Supporting real and non-real time data sets
- Supporting routine dissemination as well as request/reply mechanisms for all data and products
- Supporting various communication protocols for data transmission matching exchange requirements, from email and GTS procedures to emerging Internet standards like Web- and Grid-Services
- Using different types of communication links as available, appropriate and cost effective, including dedicated links and networks, e.g. GTS, satellites and Internet
- Using off-the-shelf hardware and software systems, preferably open source software.

To better describe FWIS, a functional view is adopted. Three major components are defined: *National Centres (NC), Data Collection or Product Centres (DCPC)* and *Global Information System Centres (GISC)* together with a data communication network connecting the components. It should be noted that the terms are only used for describing the necessary functions, not actual organisational entities. There may be organisations like NMHS's which combine all three functions within their structure.

1. National Center (NC)

Similar to the WWW distribution of functions and that of several other Programmes, e.g. JCOMM, GCOS ,..., FWIS assumes the existence of a national component. This part of FWIS is responsible for collecting and distributing data on a national basis and to authorise the use of the FWIS elements for its accredited national users. Therefore, a national authority must be established, normally the Permanent Representative (PR) of the country, to co-ordinate the use of FWIS by the different Programmes which could operate a National Centre each.

2. Data Collection and Production Centre (DCPC)

Centres which fulfil within their own WMO Programmes the responsibility of producing data and archiving the information would undertake data exchange functions within FWIS. Examples of Centres taking up those functions are the European Centre for Medium-Range Weather Forecasts (ECMWF) in Reading, UK, and national Numerical Weather Prediction (NWP) Centres.

Similarly, centres which collect information like World Data Centres e.g. in Ashville, Obninsk or Bejing or specialised agencies such as EUMETSAT and NESDIS are also responsible for storing and archiving the information and making them available for standard dissemination or on a request-reply mechanism in accordance with agreed data access policies. Furthermore, some centres would ensure the collection of data on a regional or specialised basis (e.g. ARGOS,…) and thus act as DCPC's .

3. Global Information System Centre (GISC)

The regional and global connectivity of the FWIS structure is guaranteed by the existence of a small number of core communication centres whose areas of responsibility in total cover the whole world and which collect and distribute the information meant for routine global dissemination. In addition, they serve as collection and distribution centres for their areas of responsibility and also provide an entry point for any request for data held within FWIS, i.e. they maintain metadata catalogues of all information available for any authorised user of FWIS, independent of its location or type. In addition, for all environmental data available within FWIS which are not subject to any access control, the GISC will provide a portal for data searches by anybody, even without prior authorisation. This new service will greatly facilitate data searches by researchers.

4. Network structure

The data communication network connecting the various parts of FWIS should be based on any agreed technology available to the participating centres and being capable of handling the foreseen traffic. There should be satellite communication channels as well as terrestrial links or managed data network services. Similarly, any suitable transmission protocol could be employed. The format of the selected information should be decided by the user being able to choose from a wide variety of options. Metadata information should be available in a standard format , e.g. as XML documents.

FWIS concerns only telecommunication and data management functions of the WMO and does not affect the Global Observing System (GOS), the Global Data Processing System (GDPS) of the WWW nor the data observing and data processing components of other WMO Programmes. Therefore, the impact of the proposed changes only affect those centres which are prepared to provide additional data exchange services in accordance with the concept.

Once FWIS becomes fully operational, the following services can be expected:

- for WWW, with regard to high priority time-critical data and products, the current GTS dissemination of data will continue. Any foreseeable or possible enhancement of the GTS will be supported;
- further development of satellite transmission systems will enable all participants of FWIS, in particular the least developed Members of WMO, to receive the routine global dissemination of products;
- other established international programmes can use the FWIS with agreement of WMO to transmit data either in real-time or in delayed mode. The required timeliness and size of the data determine the media to be used for the data transmission, e.g. leased lines, GTS links, Internet or satellite distribution systems. In addition, the data transmission protocol can be chosen either by the initiating programme or by each recipient from an agreed common set;
- authorised users of FWIS can ask for routine or ad-hoc dissemination of data known to FWIS;
- any user, even without authorisation, can use FWIS via Internet for data directory browsing or access to data which is available to everybody without restriction.

Since FWIS will only use off-the-shelf hardware and software systems, it should be affordable and highly flexible. Thus, in the future, emerging standards such as Web or Grid services will also be supported.
In summary, FWIS will add services to the current systems and will allow the exploitation of synergy effects by creating a single, integrated system for all WMO programmes that supports a range of data exchange services adapted to the actual requirements (timeliness, security, volumes). This would facilitate the active participation of the less developed Members in the WMO Programmes, especially the WWW.
Actual development and implementation of FWIS should be pursued through a gradual introduction and evaluation of enabling technologies through pilots and prototypes. The major innovation is needed in the development of metadata directories for which all programmes should contribute. Successful prototypes could then be expanded to serve additional communities and/or distributed to other Members and centres for wider implementation. In this way, the enhanced functions provided by FWIS would be gradually introduced and expanded.

1. Introduction

In 1998, it became apparent that the various WMO Programmes either had already or were in the process of developing their own information systems independently of each other. Since the multiplicity of systems resulted in incompatibilities, inefficiencies, duplication of effort and higher overall costs for Members, the continued development of the systems in this uncoordinated manner would have exacerbated these problems and would have further isolated the WMO Programmes from each other and from the wider environmental community. It would have increased the difficulty in sharing information between programmes, which was essential for them to fulfil their requirements. Therefore, the Commission for Basic Systems (CBS) at its Extra-ordinary session in Karlsruhe, 30 September to 9 October 1998, decided to create an Inter-Programme Task Team on future WMO information systems (IPTT on FWIS) within the Open Programme Area Group on Information System and Services with the following terms of reference (latest version from 2002, see [2]):

Focus on the long-term (4+ years) development of WMO information systems with a view toward development of implementation plans.

- *Review data exchange requirements (volume, timeliness, connectivity) of the WWW and other WMO Programmes as well as other information system requirements, from the view of the end user, in an "applications oriented manner";*
- *Review the current and anticipated capabilities of public and dedicated data communication networks and services (the Internet, FR & ATM networks, satellite-based distribution, etc) and conduct pilot studies;*
- *Develop a vision for future WMO information systems to cost-effectively meet WMO requirements for real and non real-time data exchange. This would include:*
- *Basic concepts for information handling systems (Data Bases, servers, etc.);*
- *More efficient data collection, exchange and distribution mechanisms (store-and-forward, multicast, download, etc.);*
- *cost-effective utilisation of public and dedicated data communication networks and services.*
- *Develop a project plan including proposed applications and responsibilities of centres. Propose steps toward implementation of the improved information system.*

The IPTT on FWIS has a membership of about 15 experts and met five times so far:

1. first meeting, Melbourne, 1-5 November 1999 (see [14])
2. second meeting, Monterey, CA, USA, 28 August - 1 September 2000 (see [15])
3. third meeting, Langen, Germany, 25-29 June 2001 (see [16])
4. fourth meeting, Johannesburg, South Africa, 23-27 September 2002 (see [17])
5. fifth meeting, Kuala Lumpur, Malaysia, 20-24 October 2003 (see [18]).

It created a vision for FWIS stating (see [18]):

FWIS should provide an integrated approach to meeting the requirements of:

- *Routine collection and automated dissemination of observed data and products ("push").*
- *Timely delivery of data and products (appropriate to requirements)*

- *Ad-hoc requests for data and products ("pull").*

FWIS should be:

- *Reliable*
- *Cost effective and affordable for developing as well as developed Members*
- *Technologically sustainable and appropriate to local expertise*
- *Modular and scalable*
- *Flexible and extensible - able to adjust to changing requirements and allow dissemination of products from diverse data sources and allow participants to collaborate at levels appropriate to their responsibilities and budgetary resources.*

FWIS should also support:

- *Different user groups and access policies, such as WMO Resolutions 40/25*
- *Data as well as network security*
- *Integration of diverse datasets.*

Taking into account that information systems technology is evolving rapidly, FWIS should utilize industry standards for protocols, hardware and software. Use of these standards will reduce costs and allow exploitation of the ubiquitous Internet and web services.
The ultimate implementation of FWIS would build upon the most successful components of existing WMO information systems. It would continue to rely upon the WMO communication system (initially the GTS) to provide highly reliable delivery of time-critical data and products.

During its fourteenth session in 2003, 5 to 24 May 2003, the World Meteorological Congress supported the views and conclusions of CBS that an overarching approach was required: a single coordinated global infrastructure, the Future WMO Information System (FWIS) (see [3]):

- *The FWIS would be used for the collection and sharing of information for all WMO and related international programmes.*
- *FWIS would provide a flexible and extensible structure that would allow NMHSs to enhance their capabilities as their national and international responsibilities grew.*
- *Implementation of FWIS should build upon the most successful components of existing WMO information systems in an evolutionary process.*
- *FWIS development should pay special attention to a smooth and coordinated transition.*
- *The Improved MTN would be the basis for the core communication network*
- *FWIS should utilize international industry standards for protocols, hardware and software.*
- *Pilot projects and prototypes would play an essential role in the further development of the FWIS.*

However, it was noted by the WMO Secretariat that

- there was a low level of understanding of the functional potential and expectable benefits of the FWIS;
- outside of the WWW, there is reluctance in making resources available to participate in and contribute to the FWIS development;
- there is a feeling prevalent that FWIS would eventually cater for the WWW requirements and the other programmes would play a secondary role; and
- it is necessary to take action to improve the awareness of the FWIS development within the various WMO programmes and in the relevant communities outside WMO so that WMO will succeed in achieving a truly global and inter-operable data information system.

Therefore, it was decided to provide the necessary information as this brochure for use mainly by the Technical Commissions and the Regional Associations, as well as by other communities engaged in the planning of information systems related to environmental data.

2. Background

As stated in [1],

nearly all Programmes collect data, transmit these data to one or more processing centres, perform quality control, generate products, transmit these products to users, and archive the data and products for future use. Several Programmes further divide the data flow into real-time and delayed mode data streams as shown in the figure below.

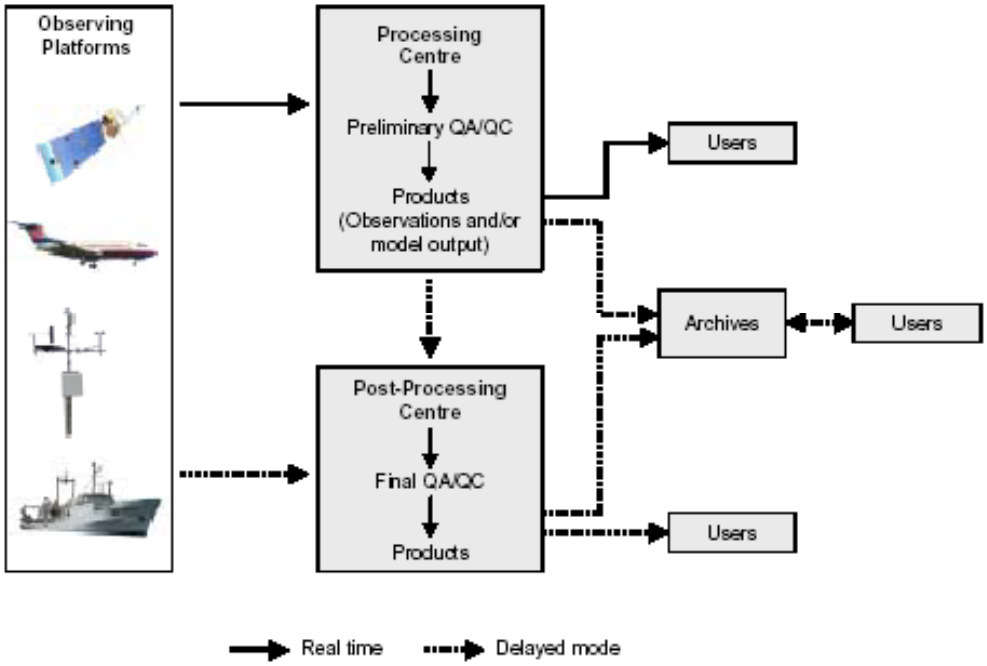

Fig. 1: Data flow for WMO Programmes

Real-time and operational data flow is often essentially one-way, that is, products are routinely transmitted to collection centres or broadcast to users without any explicit action from the

recipient. A variety of telecommunication services are used for real-time transmission including leased fixed circuits (both terrestrial and satellite) and the Internet. Delayed mode transmission utilizes the Internet, post and, less often, private circuits.
Access to data held in archives is usually provided on a two-way or request/reply basis. That is, users contact the archive, request products and these products are then transmitted to the user. Although the Internet is rarely used for real-time data transmission it is commonly used for access to archives. Several Programmes utilize the standard protocols and data representation forms of the CBS for transmission of their real-time and operational delayed-mode data.

2.1 The Global Telecommunication System (GTS)

The GTS along with the related data processing and management functions has been developed for more than 30 years to serve the World Weather Watch (WWW). It is a hierarchical structure of national, regional and global telecommunications links (see below). It uses all available transmission media, from 50 bd telegraphic lines, leased circuits, managed networks, to Internet or satellite connections with Mb/s bandwidth.

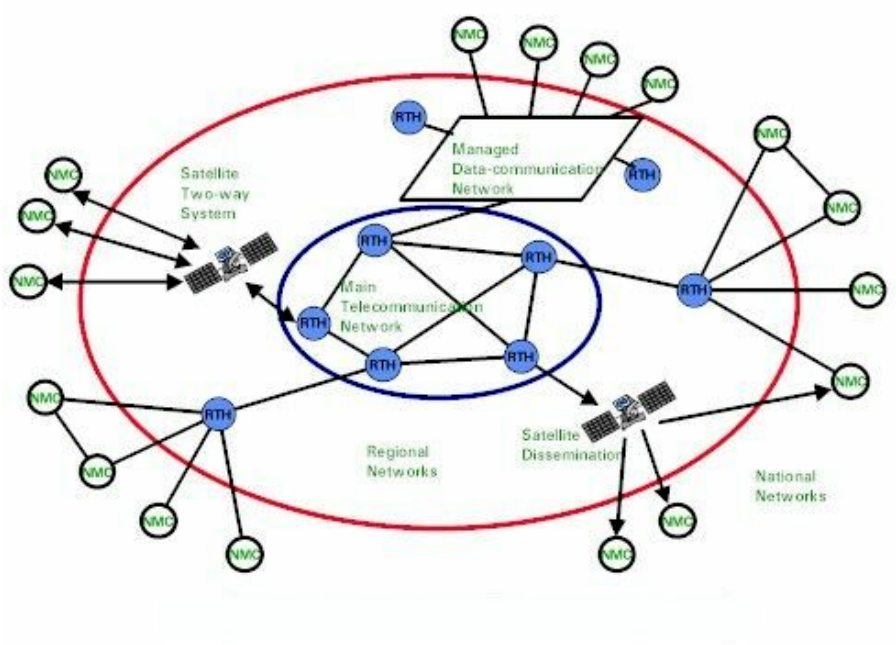

Fig. 2.: Structure of GTS

The GTS has a number of significant strengths: it is an operational private network that mainly provides for the exchange of real-time high-priority data, it is mature, well tested and operated according to well-defined procedures and shared responsibilities. However, the GTS suffers from inherent deficiencies, some of which are listed below:

- Use of proprietary high-level protocols that are not supported by the marketplace.
- Volume restrictions preclude the transmission of satellite imagery, as well as video and other high volume data sets (in the order of gigabytes or terabytes).
- Lack of support for a request/reply system providing ad-hoc access to the data and products available for international exchange.

- Inability to facilitate information insertion and distribution to programmes and public and other clients beyond the meteorological community.
- Inability to rapidly (i.e. routinely near-real-time) identify where data losses are occurring and undertake remedial action.
- Inability to easily accommodate requirements that include short periods of high volume traffic followed by lengthy periods of low or no traffic.
- Inadequate product identification and metadata leading to duplication and uncertainty of content.

As a consequence, other information systems have been developed to meet the needs of other programmes and Commissions. Given the diversity of these systems it is difficult to provide a concise summary. However, most share a common strength: they have been developed by individual programmes to meet their specific requirements. Thus, the systems are generally focused in their approach and do not suffer from compromises and inefficiencies that can sometimes result from development of generalised systems.

2.2 Data Centres and formats

Beside the centres related to the WWW, such as NMC, RSMC, WMC, RTH, etc. there exists a large variety of Centres for the various data types collected by the different programmes. They range from world data centres (WDC) for meteorology to WMO WDC for Ozone and ultraviolet radiation, greenhouse gases, aerosols, aerosol optical depth, precipation chemistry, global runoff, radiation, climate etc. All these centres collect the information they store one way or the other and make the data available to their clients using many different dissemination methods. In addition, the data formats used to store and present the data are as diversified as the Programmes they belong to. Beside a variety of ASCII based formats like FM12, CREX , etc. and binary table driven code forms such as GRIB, BUFR or NetCDF, there are also uses of XML or other formats developed for multi-media applications e.g. MPEG, GIF, etc. Similarly, the transmission protocols span the whole spectrum of available methods. They range from X.25 modified for GTS use, specialised socket connection , etc. to modern TCP/IP based services like ftp, http, SOAP or even GridFTP.

2.3 Reason for FWIS development

There is agreement within WMO that (see [1])

- A widely available and electronic (on-line) catalogue of all meteorological and related data for exchange to support WMO Programmes is required.
- It should be possible to rapidly integrate real-time and non-real-time (archive) data sets to better interpret weather events in a climatological context.
- There is a need to identify [and utilise] the potential of [data from] observation sites established by one Programme to meet the requirements of other Programmes.
- There is a need to harmonize data formats, transmission standards, archiving and distribution mechanisms to better support inter-disciplinary use of data and products.
- Standard practices for the collection, electronic archival and exchange of metadata, both high-level and detailed, especially for stations and instruments, are needed.

In view of these requirements and noting the disadvantages of the current situation as stated in para. 1. above, the WMO governing bodies decided to embark on the development of a single coordinated global infrastructure, the Future WMO Information System (FWIS). It is envisioned that FWIS would be used for the collection and sharing of information for all WMO and related international programmes.

3. Concept of FWIS

In view of the decision by the WMO Congress during its fourteenth session that "an overarching approached was required" the relationship between functions to be performed by FWIS and similar functions performed by current WMO Programmes is illustrated in Fig. 3 below.

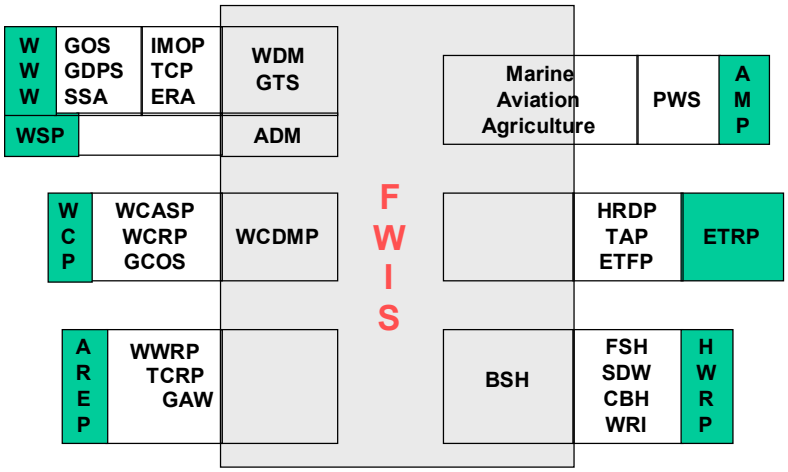

Fig. 3: FWIS relationship to WMO Programmes

Taking into account the known requirements expressed by the different Programmes as listed in the reports of the IPTT on FWIS (see [14-18]) and in [1]), the overall design of FWIS should meet the following needs as stated in [18]

- *Routine collection and automated dissemination of observed data and products ("push").*
- *Timely delivery of data and products (appropriate to requirements)*
- *Ad-hoc requests for data and products ("pull").*

FWIS should be:

- *Reliable*
- *Cost effective and affordable for developing as well as developed Members*
- *Technologically sustainable and appropriate to local expertise*
- *Modular and scalable*
- *Flexible and extensible - able to adjust to changing requirements and allow dissemination of products from diverse data sources and allow participants to collaborate at levels appropriate to their responsibilities and budgetary resources.*

FWIS should also support:

- *Different user groups and access policies, such as WMO Resolutions 40/25*
- *Data as well as network security*
- *Integration of diverse datasets.*

Taking into account that information systems technology is evolving rapidly, FWIS should utilize industry standards for protocols, hardware and software. Use of these standards will reduce costs and allow exploitation of [modern communication services, including] the ubiquitous Internet and web services.

To better describe FWIS, a functional view is adopted. Three major components are defined: *National Centres (NC), Data Collection or Product Centres (DCPC)* and *Global Information System Centres (GISC)* together with a data communication network connecting the components. It should be noted that the terms are only used for describing the necessary functions, not actual organisational entities. There may be organisations like NMHS's which combine all three functions within their structure.

3.1 National Center (NC)

Similar to the WWW distribution of functions and that of several other Programmes, e.g. JCOMM, GCOS ,..., FWIS assumes the existence of a national component. This part of FWIS is responsible for collecting and distributing data on a national basis and to authorise the use of the FWIS elements for its accredited national users. Therefore, a national authority must be established, normally the Permanent Representative (PR) of the country, to co-ordinate the use of FWIS by the different Programmes (see [5]) which could operate a National Centre each. The rôle of the National Centres (NC) was summarised as follows by the IPTT on FWIS (see [18]):

- Collect observational data from within their country
- Provide observations and products intended for global dissemination to their responsible GISC (possibly via a DCPC)
- Provide observations and products intended for regional or specialised distribution to the responsible DCPC
- Collect, generate and disseminate products for national use.
- Participate in monitoring the performance of the system
- Authorize their national users to access FWIS, as required.

3.2 Data Collection and Production Centre (DCPC)

Centres which fulfil within their own WMO Programmes the responsibility of producing data and archiving the information would undertake data exchange functions within FWIS. Examples of Centres taking up those functions are the European Centre for Medium-Range Weather Forecasts (ECMWF) in Reading, UK, and national Numerical Weather Prediction (NWP) Centres.
Similarly, centres which collect information like World Data Centres e.g. in Ashville, Obninsk or Bejing or specialised agencies such as EUMETSAT and NESDIS are also responsible for storing and archiving the information and making them available for standard dissemination or on a

request-reply mechanism in accordance with agreed data access policies. Furthermore, some centres would ensure the collection of data on a regional or specialised basis (e.g. ARGOS,…) and thus act as DCPC's .
Their rôle can be summarised as (see [18]):

- Collect information intended for dissemination to NCs within its area of responsibility (i.e. regional collections)
- Collect special programme-related data and products
- Produce regional or specialized data and products
- Provide information intended for global exchange to their responsible GISC
- Disseminate information not intended for global exchange
- Support access to their products via WMO request/reply ("Pull") mechanisms in an appropriate manner
- Describe their products according to an agreed WMO standard and provide access to this catalogue of products and provide this information as appropriate to other centres, in particular a GISC
- Ensure that they have procedures and arrangements in place to provide swift recovery or backup of their essential services in the event of an outage (due to, for example, fire or a natural disaster).
- Participate in monitoring the performance of the system.

3.3 Global Information System Centre (GISC)

The regional and global connectivity of the FWIS structure is guaranteed by the existence of a small number of GISC's whose areas of responsibility in total cover the whole world and which collect and distribute the information meant for routine global dissemination. In addition, they serve as collection and distribution centres for their areas of responsibility and also provide an entry point for any request for data held within FWIS, i.e. they maintain metadata catalogues of all information available for any authorised user of FWIS, independent of its location or type. In addition, for all environmental data available within FWIS which are not subject to any access control, the GISC will provide a portal for data searches by anybody, even without prior authorisation. This new service will greatly facilitate data searches by researchers. The rôle of a GISC is defined as (see [18])

- Receive observational data and products that are intended for global exchange from NCs and DCPCs within their area of responsibility, reformat as necessary and aggregate into products that cover their responsible area
- Exchange information intended for global dissemination with other GISCs
- Disseminate, within its area of responsibility, the entire set of data and products agreed by WMO for routine global exchange (this dissemination can be via any combination of the Internet, satellite, multicasting, etc. as appropriate to meet the needs of Members that require its products)
- Hold the entire set of data and products agreed by WMO for routine global exchange for at least 24 hours and make it available via WMO request/reply ("Pull") mechanisms

- Maintain, in accordance to the WMO standards, a catalogue of all data and products for global exchange and provide access to this catalogue to locate the relevant centre
- Provide around-the-clock connectivity to the public and private networks at a bandwidth that is sufficient to meet its global and regional responsibilities.
- Ensure that they have procedures and arrangements in place to provide swift recovery or backup of their essential services in the event of an outage (due to, for example, fire or a natural disaster).
- Participate in monitoring the performance of the system, including monitoring the collection and distribution of data and products intended for global exchange.

3.4 Network structure

The network connecting the various parts of FWIS should be based on any agreed technology available to the participating centres and being capable of handling the foreseen traffic. There should be satellite communication channels as well as terrestrial links or managed data network services. Similarly, any suitable transmission protocol could be employed. The format of the selected information should be decided by the user being able to choose from a wide variety of options. Metadata information should be available as XML documents. The envisaged network structure can be depicted as below:

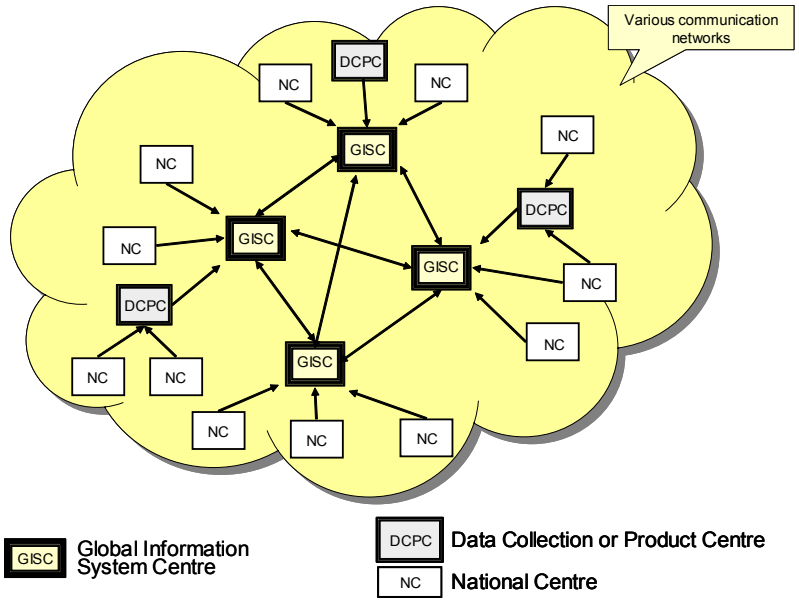

Fig. 4: Information collection data flow

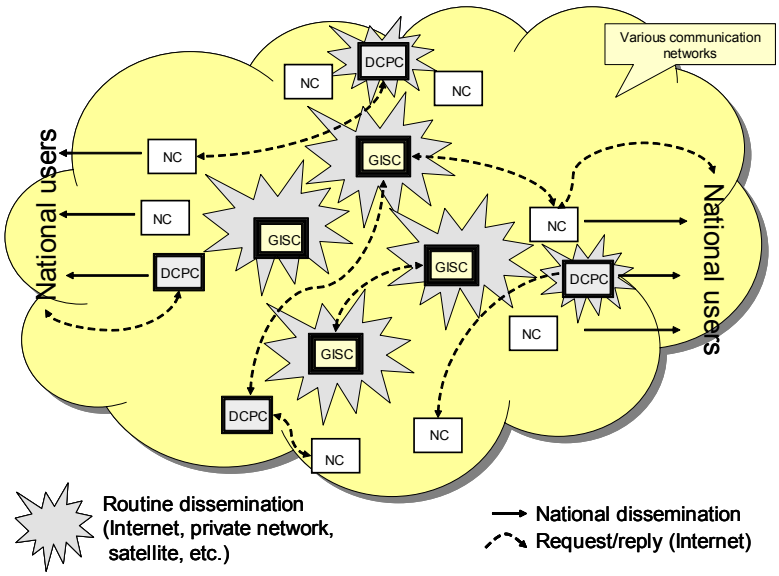

Fig. 5: Information distribution

The GTS in its entirety will be part of FWIS. The corresponding functions within FWIS of the current centres belonging to WWW or other Programmes can be seen in the following table:

Current WWW Centres	**FWIS Functions**
NMC (as regards information and communication)	NC
RSMC (as regards information and communication)	DCPC and/or GISC
WMC (as regards information and communication)	DCPC and/or GISC
RTH	DCPC
RTH on MTN	DCPC and/or GISC
Other Programme Centres	NC and/or DCPC

3.5 New features to be provided by FWIS

As stated above, the GTS will be part of FWIS and, therefore, the functions available at present will all be continued. In addition, the following new features will be added:

- Common to all WMO programmes, therefore supporting variety of data types
- Supporting real and non-real time data sets
- Supporting routine dissemination as well as request/reply mechanisms for all data and products

- Supporting various communication protocols for data transmission matching exchange requirements, from email and GTS procedures to emerging Internet standards like Web- and Grid-Services
- Using different types of communication links as available, appropriate and cost effective, including dedicated links and networks, e.g. GTS, satellites and Internet
- Using off-the-shelf hardware and software systems, preferably open source software.

3.6 Feasibility

The question arises whether the FWIS structure can actually be implemented. In order to investigate an answer to this question an architectural design study was undertaken as part of the VGISC project of RA-VI (see [7]). The following possible design emerged:

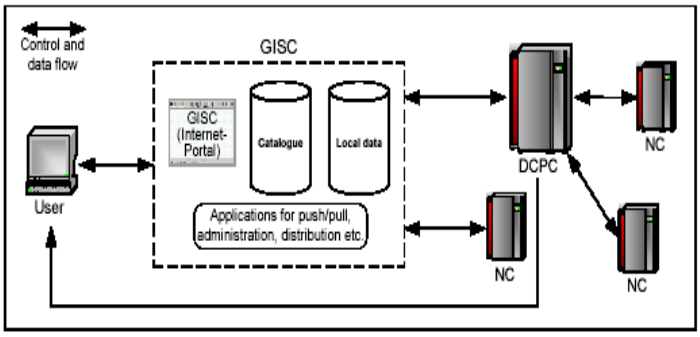

Fig. 6: FWIS design concept

In addition, a detailed design of a GISC was undertaken as well. It resulted in the following possible internal structure of a GISC:

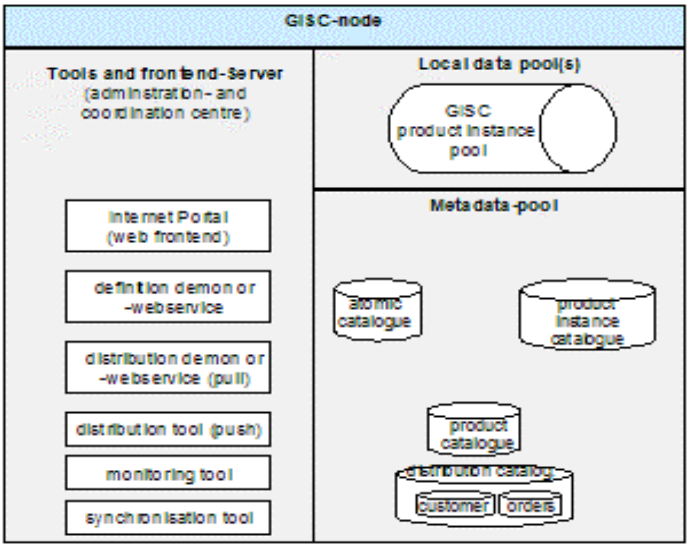

Fig. 7: Possible internal structure of a GISC

As can be seen from [7], it seems to be feasible to construct a GISC and thus the major new innovation of FWIS. It is not clear yet how many resources will be needed to actually build the first implementation, however. The greatest uncertainty lies in the area of the underlying metadata catalogue, because so far no general specification has been achieved. There is agreement amongst the WMO membership that an ISO conforming new standard has to be created but only partial implementation has been tried yet (see [19]).

3.7 Relevant activities world-wide

There are activities world-wide which provide support for some of the requirements of FWIS already. These projects are funded by various bodies some of which are unrelated to WMO. The following list is not exhaustive, but only mentions those which were brought to the attention of the IPTT on FWIS.

3.7.1 Unidata

Unidata is a diverse community of North-American education and research institutions vested in the common goal of sharing data, tools to access the data, software tools to use and visualize the data, and resources. The mission of the Unidata Program is to help researchers and educators acquire and use earth-related data. Most of the data are provided in "real time" or "near-real time" -- that is, the data are sent to participants almost as soon as the observations are made. Unidata is a data facilitator, not a data archive centre. It provides a mechanism whereby educators and researchers, by participating in the Internet Data Distribution (IDD) system, may subscribe to streams of current data that interest them (see [9]).

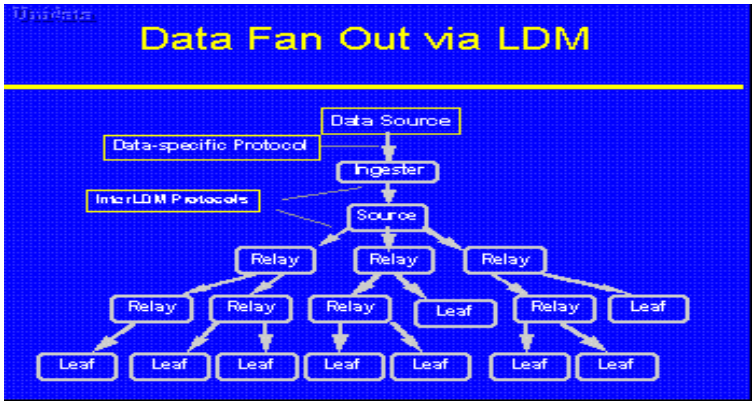

Fig. 8: IDD data distribution schema

3.7.2 CliWare

CliWare is an information system that allows authorized users to access hydrometeorological data and products over the Internet or based on a TCP/IP network. The aim of CliWare is to collect data from different data sources in different formats, to save the data in a database for a long time

and to distribute the data to users in generally well known formats. Unified request languages for data and metadata and unified data formats for data distribution allow the simplification of access to the data. CliWare is being implemented by the RIHMI-World Data Centre, Obninsk, Russian Federation (see [10]).

3.7.3 Earth System Grid

The Earth System Grid II (ESG) is a new research project (see [8]) sponsored by the U.S. DOE Office of Science under the auspices of the Scientific Discovery through Advanced Computing program (SciDAC). The primary goal of ESG is to address the formidable challenges associated with enabling analysis of and knowledge development from global Earth System models. Through a combination of Grid technologies and emerging community technology, distributed federations of supercomputers and large-scale data & analysis servers will provide a seamless and powerful environment that enables the next generation of climate research.

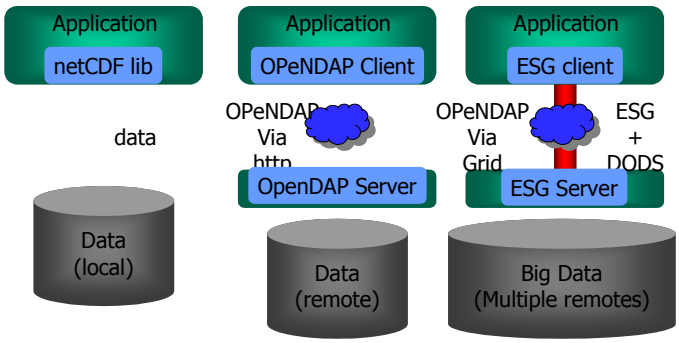

Fig. 9: ESG distributed data access

3.7.4 Community data portal

The Community Data Portal (CDP) is a collection of earth science datasets from NCAR, UCAR, UOP, and participating organizations in the following research areas:

- oceanic
- atmospheric
- space weather
- turbulence.

CDP is an NCAR Cyberinfrastructure Strategic Initiative project and is a collaboration between UCAR, NCAR, UOP, and the US National Science Foundation (see [11]).

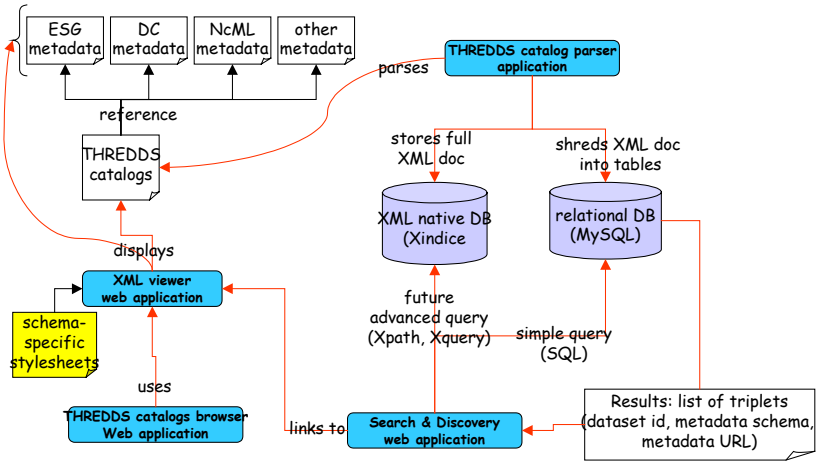

Fig. 10: Community Data Portal Metadata Software

3.7.5 NERC DataGrid

The NERC DataGrid is a project funded as part of the E-science initiative in the UK. As quoted from the project proposal (see [12]):

The NERC DataGrid proposal is to build a grid which makes data discovery, delivery and use much easier than it is now, facilitating better use of the existing investment in the curation and maintenance of quality data archives. Further it intends to make the connection between data held in managed archives and data held by individual research groups seamless in such a way that the same tools can be used to compare and manipulate data from both sources. What will be completely new will be the ability to compare and contrast data from an extensive range of (US, European, UK, NERC) datasets from within one specific context. It will be building on technology developments carried out primarily in the US by collaborators from the Earth System Grid.
Although there are no direct environmental science goals to be funded within this project, the underpinning technology that it will create will find immediate use in many aspects of atmospheric and oceanographic science. The presence of the NERC DataGrid will allow grid based visualisation services to access a wide variety of data held at the British Atmospheric and Oceanographic Data Centres (BADC and BODC respectively) as well as on individual storage systems belonging to groups which register their data with the NERC DataGrid. The structures put in place will also allow NERC data to become part of the putative future semantic grid.

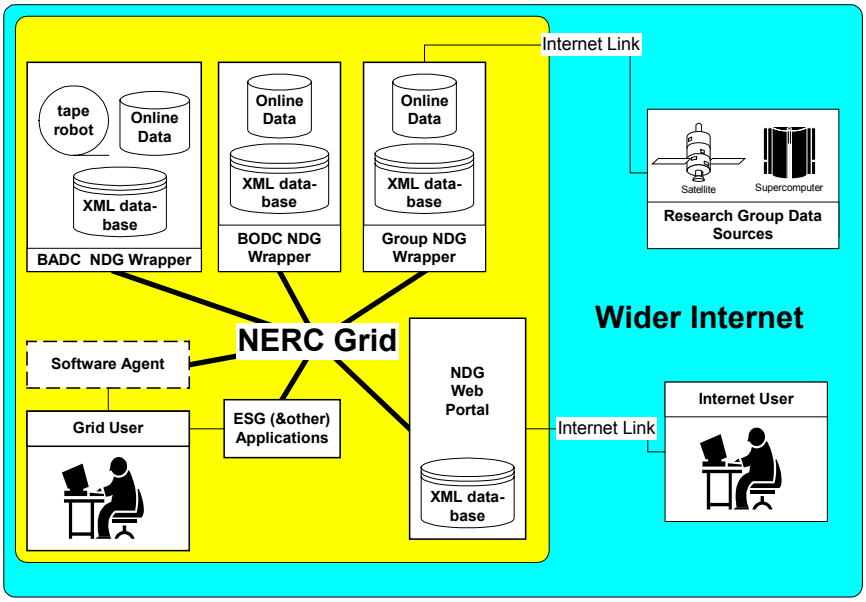

Fig. 11: NERC DataGrid

3.7.6 UNIDART

The UNIDART Programme (Uniform Data Request Interface) has as its main goal the development of a meteorological Web portal which will provide uniform access to

meteorological data and products through the Internet. It is funded by EUMETNET (see [13]), the network of 18 national meteorological services in Western Europe. EUMETNET provides a framework to organise co-operative programmes between the Members in the various fields of basic meteorological activities such as observing systems, data processing, basic forecasting products, research and development, training. Through EUMETNET Programmes, the Members intend to develop their collective capability to serve environment management and climate monitoring and to bring to all European users the best available quality of meteorological information. They will use EUMETNET to make more efficient the management of their collective resources.

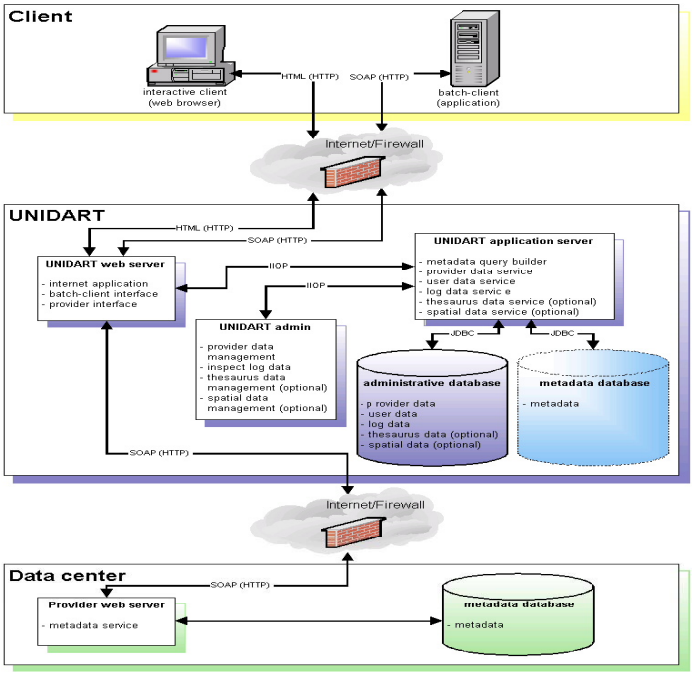

Fig.12: UNIDART structure

4. Impact and benefits for WMO

First of all it should be noted as stated in [5]

FWIS concerns only telecommunication and data management functions of the WMO and does not affect the Global Data Processing System (GDPS) of the WWW or the data processing components of other WMO Programmes.

Therefore, the impact of the proposed changes only affect those centres which are prepared to provide additional data exchange services in accordance with the concept. However, why should Members of WMO shoulder the additional responsibilities and the related costs? The major reason is, again, given in [5]

FWIS is intended to serve all relevant WMO programmes. It would bring savings to the meteorological/hydrological community as a whole and increase efficiency of their operations.

Therefore, the different programmes gaining from the synergy savings, implicit in FWIS, should be prepared to invest in its implementation and maintenance. The first step would be for the large RTH's associated with global numerical modelling centres to develop and implement a metadata catalogue and to expand the present RTH services to include a request/reply mechanism, thus de facto becoming the nucleus of a GISC. They could initially support their in-house DCPC. This would allow the least developed Members, for the first time, to actively participate in the WMO Programmes, especially the WWW. Fig. 13 below provides the framework of possible development. The newly created GISC's would then implement the global data exchange envisaged in the concept. As a next step, various DCPC's could offer their data for access and ease the burden for the related programmes. Furthermore, at this stage the different programmes could extend the metadata catologue held in the GISC's by their own special data requirements and use the FWIS features to disseminate their products. By giving the NC's the task to authorise the users of FWIS,

the introduction of FWIS could provide Permanent Representatives (PR) with an opportunity to increase the visibility and capability of the NMHS, enhancing the role of the NMHS as the national focal point for information services to many new user groups within the country (see [5]).

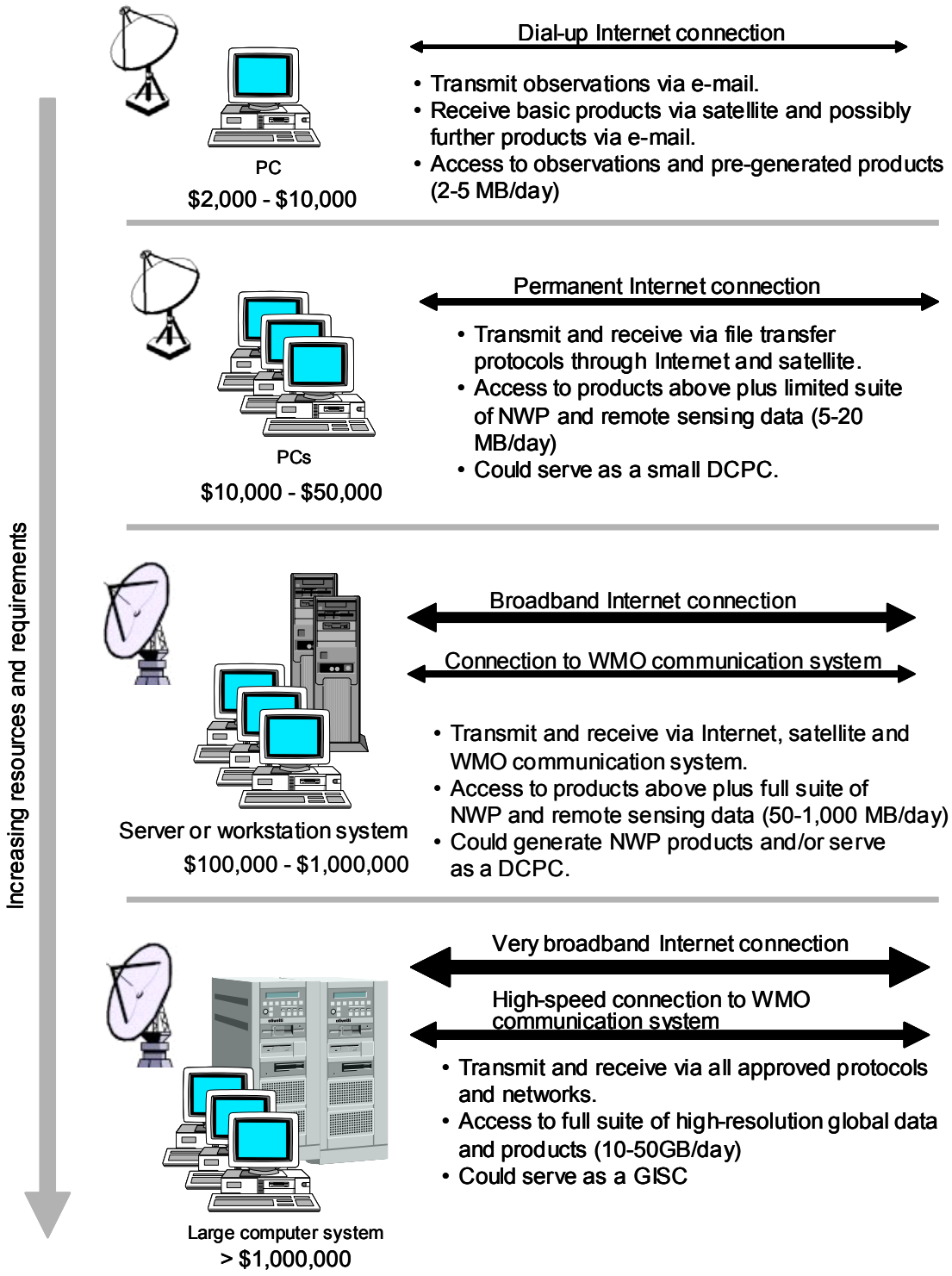

Fig. 13: Possible development path for FWIS systems

Once FWIS becomes fully operational, the following services can be expected:

- for WWW, with regard to high priority time-critical data and products, the current GTS dissemination of data will continue. Any foreseeable or possible enhancement of the GTS, like the IMTN, will be supported;
- further development of satellite transmission systems will enable all participants of FWIS, in particular the least developed Members of WMO, to receive the routine global dissemination of products;
- other established international programmes can use the FWIS with agreement of the WMO to transmit data either in real-time or in delayed mode. The required timeliness and size of the data determines the media to be used for the data transmission, e.g. leased lines, GTS links, Internet or satellite distribution systems. In addition, the data transmission protocol can be chosen either by the initiating programme or by each recipient from an agreed common set;
- authorised users of FWIS can ask for routine or ad-hoc dissemination of data held in a GISC or in a DCPC via a request system. Depending on the integration of a DCPC with its related GISC, data may be sent directly or the user additionally has to contact the DCPC for data access;
- any user, even without authorisation, can access any GISC via Internet for data directory browsing or access to data which is available to everybody without restriction.

Since FWIS will only use off-the-shelf hardware and software systems, it should be affordable and highly flexible. Thus, in the future, emerging standards such as Web or Grid services will also be supported.
Beside the programmes which could benefit from the services offered by FWIS for the implementation of their data exchange tasks, the individual users, either a person or an institution, would be the main beneficiary of FWIS, because FWIS would provide a single entry point for any data request, be it on a routine basis by dissemination of certain user defined information sets or on an ad-hoc basis for a special data set. The current diversification of access points and –methods would be replaced by a common approach. Furthermore, the portal structure provided by GISC would make it possible for programmes to present their data to their users in a programme specific query format.
In summary, FWIS will add services to the current systems and will allow the exploitation of synergy effects by creating a single, integrated system for all WMO programmes that supports a range of data exchange services adapted to the actual requirements (timeliness, security, volumes).

5. Future actions

The first step as outlined above is the development of a prototype GISC based on an RTH infrastructure. The structure of a GISC can be visualised as seen in Fig. 14.

It is obvious that the central part of the innovative GISC development is the metadata catalogue. In more detail, the metadata catalogue has to be seen as four closely integrated sub-catalogues

- the atomic catalogue for defining the inseparable items of information, the “atoms”;
- the product catalogue for defining the sets of atoms which together form a “product”;

- the product instance catalogue which defines the current state of available products and their composition, and
- the distribution catalogue which lists the recipients of the product instances, the dissemination types, the preferred way of dissemination etc.

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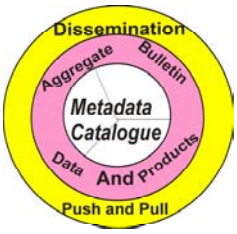

Fig. 14: Layered structure of GISC

The detailed structure is shown below:

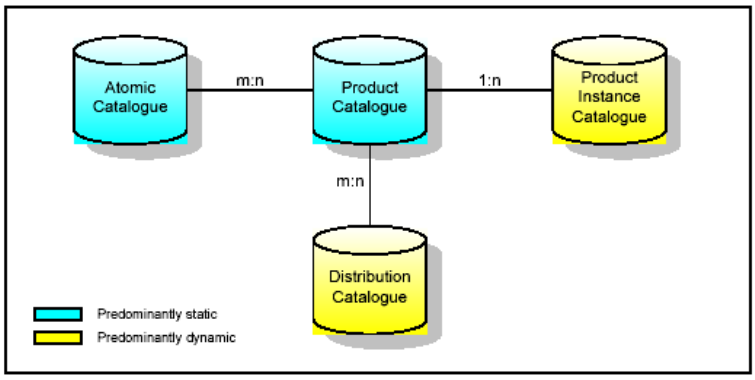

Fig. 15: GISC catalogues

As an example, of how a request/reply mechanism could be constructed, the following structure is depicted (see [7]):

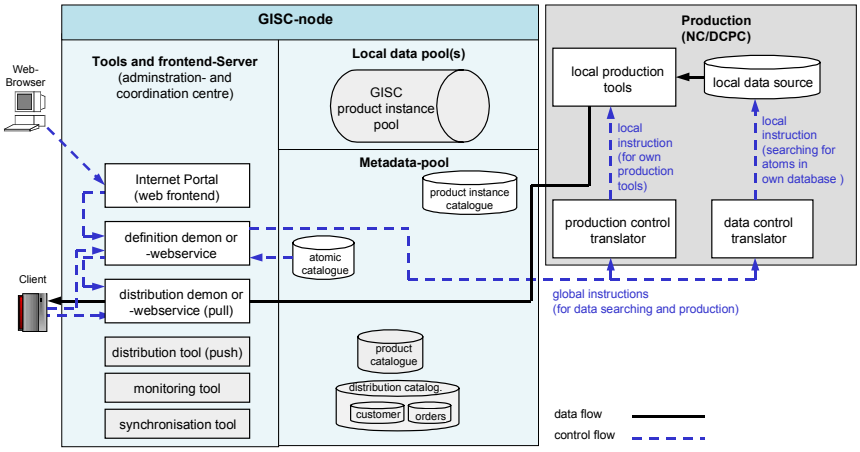

Fig. 16: Request/reply mechanism

Based on these ideas, the VGISC project in RA-VI is in the process of implementing such a GISC prototype (see [6]). It is expected that a proof of concept, in particular in relation to the metadata directory structure, will be ready for presentation at the forthcoming CBS meeting. There are also plans in other RA's, e.g. RA-II , to develop GISC implementations, and it is hoped that as part of a planned FWIS workshop to be held in conjunction with the extra-ordinary meeting of CBS in 2006, the interoperability of GISC's can be demonstrated. However, as stated by the WMO Executive Council in 2003 (see [4]):

The support and involvement of regional associations and technical commissions [is] needed, as early as possible, in all phases of the FWIS development in order to ensure a full and shared ownership of the project, and its effective implementation.

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7. List of acronyms

ADM	Alternative dissemination methods
AMP	Applications of Meteorology Programme
ASCII	American Standard Code for Information Interchange
ATM	Asynchronous Transfer Mode
BADC	British Atmospheric Data Centre
BODC	British Oceanographic Data Centre
BUFR	Binary Universal Form for the Representation of meteorological data
CBH	Capacity Building in Hydrology and Water Resources
CBS	Commission for Basic Systems
CDP	Community Data Portal
Cg	WMO Congress
CREX	Character Representation form for data Exchange
DAP	Data Access Protocol

DB	Data Base
DCPC	Data collection or product centre
DMAC	Data Management and Communications of the Integrated Ocean Observing System
DWD	Deutscher Wetterdienst (German Weather Office)
EC	Executive Council of WMO
ECMWF	European Centre for Medium Range Weather Forecasts
ERA	Emergency Response Activities
ESG	Earth System Grid
ET	Expert team
ETFP	Education Training and Fellowships programme
ETRP	Education and Training Programme
EUMETNET	European Meteorological Network (18 national meteorological services)
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites.
FM12	Report of surface observation from a fixed land station
FR	Frame Relay
ftp	File transfer protocol
FWIS	Future WMO Information System
GAW	Global Atmosphere Watch
GB	Gigabyte, 10^9 octets
GCOS	Global Climate Observing System
GDPS	Global Data Processing System
GIF	Graphics Interchange Format
GISC	Global information system centre
GOS	Global Observing System
GRIB	FM 92-VII Ext-GRIB (Gridded Binary) processed data in the form of grid-point values expressed in binary form
GridFTP	Universal data transfer for the Grid (http://www.globus.org/datagrid/deliverables/C2WPdraft3.pdf)
GTS	Global Telecommunications System
HRDP	Human Resources Development programme
http	Hypertext Transfer Protocol
HWRP	Hydrology and Water Resources Programme
IDD	Internet data distribution system
IMOP	Instruments and Methods of Observations programme
IMTN	Improved MTN
IPTT	Interprogramme Task Team
ISO	International Standards Organization
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
LDM	Unidata's local data manager of IDD
MB	Megabyte, 10^6 octets
MPEG	Moving Picture Experts Group
MTN	Main Telecommunications Network (of the GTS)
NC	National Centre
NCAR	National Center for Atmospheric Research
NcML	NetCDF Markup Language
NDG	NERC Data Grid

NERC	Natural Environment Research Council
NESDIS	National Environmental Satellite, Data and Information Service
NetCDF	Network Common Data Form
NMC	National Meteorological Centre
NMHS	National Meteorological or Hydrological Service
NWP	Numerical Weather Prediction
OPeNDAP	Open Source Project for a Network Data Access Protocol
PC	Personal computer
PR	Permanent Representative
PWS	Public Weather Services
RA	Regional Association
RA-VI	Regional Association VI of the WMO (covering mainly Europe)
RSMC	Regional Specialised Meteorological Centre
RTH	Regional telecommunications hub
SDW	Sustainable Development of Water Resources
SOAP	Simple Object Access Protocol
SSA	System Support Activities
SYNOP	Colloquial name for code form FM 12 IX
TAP	Training Activities programme
TCP	Tropical Cyclone programme
TCP/IP	Transport control protocol, internet protocol
TCRP	Tropical Cyclone Research Programme
UCAR	University Corporation for Atmospheric Research
UNIDART	Uniform Data Request Interface
UOP	University of Phoenix
VGISC	Virtual Global information system centre
WCASP	World Climate Applications and Services Programme
WCP	World Climate Programme
WCRP	World Climate Research Programme
WDC	World Data Centre
WDM	World Weather Watch Data Management
WMC	World Meteorological Centre (Melbourne, Moscow, Washington)
WMO	World Meteorological Organization
WRI	Water-related Issues
WSP	WMO Space Programme
WWRP	World Weather Research Programme
WWW	World Weather Watch
X.25	Commonly used network protocol adopted by the CCITT
XML	Extensible mark-up language