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State of Information Technology and Its Application in Agricultural Meteorology

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농업기상활용 정보기술 현황

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ABSTRACT

Grid is a new Information Technology (IT) concept of "super Internet" for high-performance computing: worldwide collections of high-end resources such as supercomputers, storage, advanced instruments and immerse environments. The Grid is expected to bring together geographically and organizationally dispersed computational resources, such as CPUs, storage systems, communication systems, real-time data sources and instruments, and human collaborators. The term "the Grid" was coined in the mid1990s to denote a proposed distributed computing infrastructure for advanced science and engineering. The term computational Grids refers to infrastructures aimed at allowing users to access and/or aggregate potentially large numbers of powerful and sophisticated resources. More formally, Grids are defined as infrastructure allowing flexible, secure, and coordinated resource sharing among dynamic collections of individuals, institutions and resources referred to as virtual Organizations. GRID is an emerging IT as a kind of next generation Internet technology which will fit very well with agrometeorological services in the future. I believe that it would contribute to the resource sharing in agrometeorology by providing super computing power, virtual storage, and efficient data exchanges, especially for developing countries that are suffering from the lack of resources for their agmet services at national level. Thus, the establishment of CAgM-GRID based on existing RAMINSII is proposed as a part of FWIS of WMO.

Key words : **Grid, IT, distributed resource, Internet, CAgM, FWIS, Agrometeorology, Agrometeorological products, Web service**

I. AGROMETEOROLOGICAL PRODUCTS

For the development of Agrometeorological applications, we should take many steps from collecting raw data to final delivery to end-users. Depending upon user requirements and resources available, diverse IT are employed to elaborate and improve the quality and quantity of Agrometeorological applications that can reflect region-specific demands with better efficiency in mobilizing resources available. Agrometeorological information is also provided in diverse ways and formats: Unique formats have been employed in their contents, the methods of delivery, etc. Information providers also should communicate with end-users, including feed-back from end-users. In addition, analysis tools on raw materials as well as human

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resources with appropriate expertise are required.

1.1. Components of agrometeorological products

The common features of Agrometeorological applications include general descriptions of Agrometeorological characteristics of certain regions during the specific growing season reflecting regional priorities in terms of agricultural production and resource management. Depending on the requirements and priorities of end-users, the description details or expertise levels of the contents vary to a great extent.

1) End-Users
   - Farmers, Associations, Extensions, Researchers, Policy-Makers, Publics, Stake-holders
2) Communication
   - Sharing, Dissemination, Feed-back
3) Form : Digital / Document based (Paper)
   - Bulletin, Brochure, Letter, Note, Leaflet, etc.
4) Data Format
   - Text, Numeric, Table, Chart, Figure, Image, Map, etc.
5) Methods
   - Phone, Fax, TV, Radio, PC-Network, Internet, Dedicated line, etc.
6) Contents :
   - Type : General, Advisory, Warning, Recommendation, Suggestion
   - Weather/Climate/Forecast/Prognosis/Diagnosis information
   - Extremes, Special Weather Phenomena, Energy Balance(Flux)

   (Flood, Drought, Frost, Heat Wave, Fire, Land Slide, Cold Injury, etc)
   - Crop, Fruit, Grass, Forest, Animal Husbandry, Fishery
   - Growth, Development, Yield, Population, Reproduction

   (Phenological data, Eco-physiological parameters, etc.)
   - Disease, Insect, Pest, Weeds
   - Farm Management

   (Cropping, Irrigation, Sowing, Harvesting, Post-Harvest, Spaying)
   - Resource Management (Water, Air, Soil, Biome)
7) Developers/Producers/Authors/Publishers/Editors
   - Meteorologists, Agronomists, Entomologists, Ecologists, Agrometeologists, Soil scientists, Virologists, Epidemiologists, etc.
8) Raw Materials : Meteorological, Agronomical data, non-Agricultural data
   - Observed, Processed, Derived, Estimated (inter-/extrapolated)
   - NWP Model Outputs, Agricultural Model Outputs
   - Domestic or Foreign Origin
9) Tools
   - Statistical packages, Graphic tools, GIS, Simulation models,
10) Institution/Organization
   - Meteorological, Agricultural, Hydrological, Others
   - Research Institute, Extension Office, University, Private Sector, Cooperation
   - Local, Central (Federal), Regional, Global Organizations

1.2. Types of agrometeorological information

Any products should contain enough information to meet user requirements with the highest priorities in the region. In order to reflect these requirements, diverse data, tools, skills, techniques etc. should also be available to disseminate products that have desirable levels of accessibility, relevance, timeliness, and accuracy.

Methods for the delivery of Agrometeorological information can be classified into different groups depending on format and delivery. There may be several groups of methods of the communication of Agrometeorological information after combining format and delivery types into document-based, media-based, telecommunication-based, computer network-based, and digital file-based methods.

1) Formats of information
   - Documents, Video, Audio, Computer Digital
2) Methods of Delivery
   - Mail, Broadcast, Phone, Facsimile, Network, by Hand
3) Combined Classification
   - Document-based
     Bulletins, Brochures, Letters, Notes, Others
   - Media-based
     Radio, TV Public, CATV, satellite Journals
     Newspapers General, Agriculture Magazines
     Monthly, Quarterly, Others
     Scientific Journals

- Telecommunication-based
  Phone, Fax, Mobile, PDA Others
- Computer Network-based
  PC-Network, Internet web, ftp, gopher, e-mail
- Digital File-based
  CD, Floppy, Tape, ...

1.3. Requirements for better products

1) Contents : Accessibility, Timeliness, Relevance, Accuracy
Quality Specialization, Expertise, User-oriented, Appropriateness, Feasibility
Quantity Diversity, Extended Coverage, Detailed Description
Standardization format, lay-out, processes, Timeliness Information (in advance or forecast-based), on-time Delivery
Efficiency Automation of processes (drawing, coloring, editing, printing, etc.)

2) Tools : Easy, User-friendly, Cost effective, Compatible, Standardized,
Statistical packages
Image Processing
Presentation tools
Analysis tools
Simulation Models
Systems : Decision-Making Support System, Expert System
GIS/RS Technology

3) Resources : Accessibility, Continuity, Sufficiency, Reusability
Raw Data : Meteorological, Agricultural, Non-Agricultural
Expertise
Computers
Networks
Interfaces
Infrastructure
Organization

4) Applications : Diversity, Differentiated, Applicability, Practicability,
Farm management
Food security
Market Implications
Early Warning
Risk Management
Resource Management

5) Collaborations : Continuity, Cost/Benefit, Willingness
Domestic
Regional
International

6) Communication : Accessibility, Cost Effectiveness, Performance,
User-friendly
Information Network
Interface
Skills
Feedback

7) System Operation : Performance, Relevance, Easiness, Cost Effectiveness
Server
DBMS

8) Processing/Manipulation/Preparation : Timeliness, Feasibility, Smoothness,
: data>information>bulletin>on-site application

9) Economic Value/Benefits
Final decision on new system will be made by Economic value or Social Benefits of applications

10) Special Edition
Explanatory or Evaluative descriptions on abnormal or extreme weather phenomena with their consequences or impacts on Agriculture can be published in a special edition of the bulletin whenever needed.

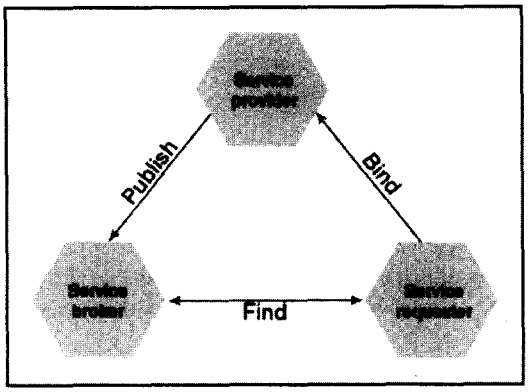
II. NEW IT TECHNOLOGIES

2.1. Web Services : next generation WWW

Web Services are self-contained, modular applications that can be described, published, located, and invoked over a network, generally the Web. The Web Services architecture is the logical evolution of object-oriented analysis and design, and the logical evolution of components geared towards the architecture, design, implementation, and deployment of e-business solutions. Both approaches have been proven in dealing with the complexity of large systems. As in object-oriented systems, some of the fundamental concepts in Web Services are encapsulation, message passing, dynamic binding, and service description and querying. Fundamental to Web Services, then, is the notion that everything is a service, publishing an API for use by other services on the network and encapsulating implementation details.

The fundamental roles in Web Services are service providers, service requesters, and service brokers.

Publish, find, and bind



These roles have operations: publish, find, and bind. Operation intermediation occurs through environmental prerequisites, and it introduces aspects such as security, workflow, transactions, billing, quality-of-service, and service level agreements. The mechanism of service description language is key to fundamental operations in Web Services. A complete description of a Web Service appears in two separate documents: a Network-Accessible Service Specification Language (NASSL) document and a Well-Defined Service (WDS) document.

The Web Services architecture provides several benefits, including:

- Promoting interoperability by minimizing the requirements for shared understanding
- Enabling just-in-time integration
- Reducing complexity by encapsulation
- Enabling interoperability of legacy applications (IBM Web Services Architecture Team (karlgott@us.ibm.com))

2.2. GRID : next generation Internet

It is difficult for us to understand exactly what the Grid is, because Grid is new technology and we are not the Information technicians. We are familiar with what the Internet is now, but a few years ago Internet, WWW, e-mail were not common words. The development speed of networks is faster than the development speed of processors; there is a performance difference between network and computer. Computer speed doubles every 18 months, but the network speed doubles every 9 months; this makes the difference an order of magnitude per 5 years.

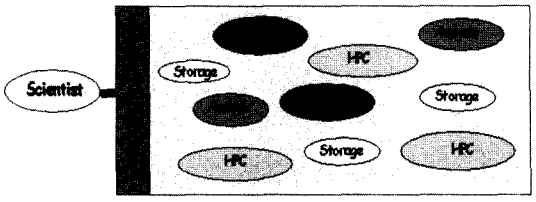
There was much research for distributed computing, sometimes called meta computing, around the late 80s. Meta computing focused on distributed computation by network. In the early 90s gigabit testbeds were founded and used as research. The term "the Grid" was coined in the middle 1990s to denote a proposed distributed computing infrastructure for advanced science and engineering by the book, "The Grid: Blueprint for a New Computing Infrastructure" written by Foster, I. and Kesselman C. Considerable progress has since been made on the construction of such an infrastructure, but the term "Grid" has also been conflicted, at least in popular perception, to embrace everything from advanced networking to artificial intelligence.

The real and specific problem that underlies the Grid concept is coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organizations. The sharing that we are concerned with is not primarily file exchange but rather direct access to computers, software, data, and other resources, as is required by a range of collaborative problem-solving and resource brokering strategies emerging in industry, science, and engineering. This sharing is, necessarily, highly controlled, with resource providers and consumers defining clearly and carefully just what is shared, who is allowed to share, and the conditions under which sharing occurs. A set of individuals and/or institutions defined by such sharing rules form what we call a virtual organization (VO).

Definition of Grid

"GRID differs from www that can use only Hyper Text as a resource. However, GRID is a communication service that is able to use a variety of different forms of databases and equipments" and "while WWW gave a taste of information technology, GRID will give a vision."

For more understanding, Grid can be compared with an electronic power grid. "The Internet is considered to



be similar to an electricity grid providing computing instead of electricity. The userplugs into the Internet and receives computing services when using the right equipment. The electricity utility is replaced by computing service providers. *"The Grid: Blueprint for a New Computing Infrastructure. I. Foster, C. Kesselmann (eds.). 1999."*

Classification of Grids

To understand the Grid concept, it is useful to classify the contents of Grids; usually there are three kinds of classes in Grids: computational grid, data grid and access grid. The computational grid is a virtual metacenter, and computing resources to provide the computing power based on network distributed computing. A super computer center's collaboration with a high speed network is an example. Data grid is the large-scale data processing and management operations that require participation of worldwide researchers. The last access grid is important because this is the human interface for computational grid and data grid. An example is a real time video conference with P2P based remote control.

So network, computer, applications and human resource are important and the 4As are:

- Advanced Network: Intelligent Network, Grid Network
- Advanced Computer and Equipment (High performance computers and high tech equipments)
- Advanced Application (New application theme, GRID application project)
- Advanced Human Resource (Science and Technology manpower, GRID users)

Example of Grid project

The U.S.A has been a leader and a competitive power in this field by pursuing various Grid projects centered at super computer centers and government affiliated research institutes since 1998. The European Union has been pursuing the European Data Grid, Euro Grid and other projects based on TEN-155 since 1999 to bring together the research abilities of its members for realizing eEurope earlier than they planned. Japan has led IT technology and basic sciences in Asia by

Project Name (USA)	Network Used	Computer and Equipment	Participating institute
SETI@Home (Search for extraterrestrial intelligence)	Abilene, vBNS, Commercial ISP	- Ten thousands of home PCs - Radio Telescope	University of Berkeley
HGP(Human Genome Project)	Abilene, vBNS	- Super computer - Large scale storage system - Sequencing machines	DoE and research institutes affiliated with NIH
NASA IPG (Construction of aeronautical devices)	NREN	- Super computer - Large scale storage system - CAVE and others	Three super computer centers at NASA

Project Name (JAPAN)	Network Used	Computer and Equipment	Participating Institutes
AP GRID (Connection of supercomputers among Asian countries)	SINET/IMNET	-Super computer	TACC
HEP GRID (Reserarch for High Energy physics)	SINET/IMNET	- Super computer - Large scale database server - Accelerator	KEK University of Tokyo

Project Name (EU)	Network Used	Computer and Equipment	Participating Countries
European Data GRID (Support for the basic sciences)	TEN155	- Super computer - Large scale database server - Accelerator	Italy, France, England, Netherlands and others
Euro GRID(Support for industrial technologies)	TEN155	- Super computer - Large scale storage system	England, Switzerland and others

pursuing Gird projects, centered at government affiliated research institutes and universities, since 2000.

Possibility of Grid in Meteorological Applications

Numerical modeling for weather or climate research and local weather forecasts, where "local" means either place or residence or current location, providing weather on demand are possible appplications. Dr. Hoffman at the ECMWF workshop proposed Grid as a WMO RSMC function used by other meteorological services. GTS protocol is changing from X.25 to TCP/IP. If the members of WMO have another Internet to exchange their meteorological data, this is the time to consider adopting the new technology to enhance cooperation. Another example is Virtual GISC based on FWIS concept.

2.3. GRID service : Web service+GRID

(http://www-1.ibm.com/grid/grid_what_is.shtml)

Distributing resources with OGSA

OGSA describes and defines a Web services-based architecture composed of a set of interfaces and their corresponding behaviors to facilitate distributed resource sharing and accessing in heterogeneous dynamic environments (see Resources). OGSA relies on the definition of Grid services in WSDL, which defines the method names, parameters, and their types for Grid service access. Figure 1 shows the OGSA architecture.

Figure 2 illustrates a Hub-style Grid solution system that uses a logical Grid for service outsourcing. This solution scenario is a typical collaborative logical Grid solution for business process integration. So we also refer to this logical Grid as a "Business Grid." In Figure 2, every service can be deployed as a Grid service so that it can be used and accessed by other applications using a standard communication protocol, such as the *Simple Object Access Protocol* (SOAP). The Business Grid cloud connects to all the services hosted by the Business Grid (Hub) itself or service providers registered with the Business Grid. Application clients can use XML, SOAP over HTTP, SMTP, FTP, or the MQ protocol to connect to the Business Grid. The Business Grid communicates with external legacy applications, Web services providers, customer's Supply Chain Management (SCM), Supplier's Enterprise Relationship Planning (ERP), or Partner's Customer Relationship Management (CRM). The Business Grid takes care of interoperability for connecting to multiple parties using different transports, data formats, and business protocols by offering a membership management service, data format translation service, business protocol translation service, advanced discovery service, and business flow management service.

III. COLLABORATION FRAMEWORK FOR AGROMETEOROLOGY BASED ON GRID TECHNOLOGY

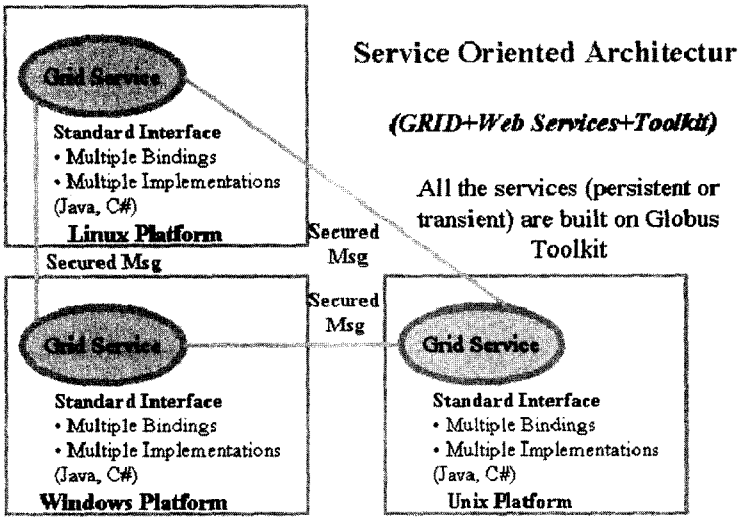


Fig. 1. OGSA architecture

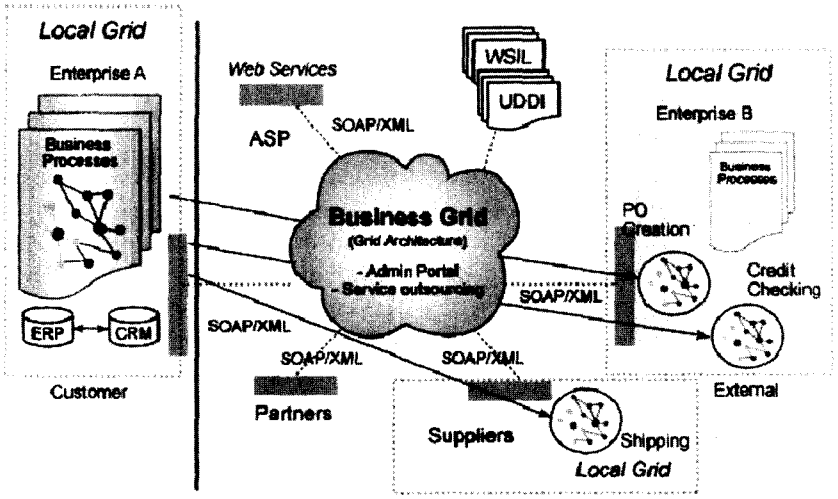


Fig. 2. An example Grid service outsourcing diagram.

3.1. Name of project (provisional)

CAgM GRID based on Regional AgroMeteorological Information Network System in Asia

Background of Cooperation

- AgroMeteorological information is the most essential resource in Agriculture; thus almost all agricultural activities are prone to changes in weather and climate.
- Increasing demands for regional non-climate/ meteorological data, for example surface vegetation and soil moisture status from Agronomic sector, for better long-term climate forecast
- AgMet information sharing among countries is the most critical and dynamic aspect in Sustainable Agriculture
- New establishment of Core AgMet Station being recommended by CAgM of WMO (1999) will require own information sharing systems for communications among member countries.
- Existing WMO GTS will not be sufficient enough to meet this requirement in terms of Network performance because it is already suffering from traffic bottlenecks.
- Inevitable use of Information Technologies such as information network, database, simulation models, GIS, RS for regional impact assessment of environmental change on AgroEcosystem
- Willingness to share resources available among countries will be a promising way to solve Regional food security problems.

3.2. Outline of the proposal

(1) Objectives

- To establish a high performance computing network for AgroMeteorological Information in Asia using Asia-Pacific Advanced Network (APAN) at the minimal cost
- To identify available resources and make them available to the public in the region with very high efficiency employing Distributed Object Architecture
- To provide diverse Broker-based information on Web service interfaces that can mediate resources between End-user and Developer/ Information Provider.

(2) Details

Systems

- GRID Servers for Simulation models, Databases, System Analysis
- High speed network frame (APAN)
- Web service interfaces for simulation models with near real time DB access
- Multi-tiered Interface Architecture under distributed computing environment

Information

- Existing DB : RS, Agronomy, Management, Climate, etc. (MAFFIN, FAO, IRRI, NOAA NCEP)

- Met Data resource : Synoptic data, Forecasts(S,M,L), Prognosis, Adaption data
- Development tools : Simulation models for climate, crop, resource management, root zone dynamics, farm management, etc.
- Derived Products : Climate change scenario, seasonal- and interannual-forecasts, crop growth and development, regional food demand/ production, etc.

Interfaces

- TCP/IP based Internet Web service interface with GUI (JAVA)
- Object Oriented Client/Server architectures with free of OSs, languages, platforms, networks. (SOAP/WSDL)
- Multi-directional communication networks between end-users and researchers (GRID)

Operations

- Contributions from member countries: Facility, equipment, space, manpower, operational costs, hardware, software, upgrade, feedback, evaluation, etc.

(3) Forms

Collaborative/Joint Development by voluntary persons, institutes, regional organizations

Japan

- NARC : Core Secretary Office, General Administration
  Infrastructure/Architecture Development
  (Dr. Seishi Ninomiya, Co-Coordinator)
- NIAES : Climate Change Information
  GHG flux Information
  Climate Change Impact Assessment Tools
  Crop-Simulation Models
  Asia AgMet Committee(Japan/Korea/China) : Joint AgMet Society in future
  (Drs. Hayashi, Harazono, Kobayashi, Toritani, 1 more):
  (Profs. J. I. Youn, B.W. Lee, J.T. Lee, J. Kim for Korea)
  (Dr./Prof. Lin Erda, Wang Shili, other 2 from China)
- MAFFIN : Center of Ag-Archives & Computer Management
  Key Ag-DB and -Application Servers
  RS, Mesh Met data, Models, Library etc.
  (Mr. Akira Mizshima)

Korea

- KMA : Meteorological Information Provider
  World Climate Data (APCN)
  Long-term forecast data
  Adaption Data
  User Interface and Object Broker Technology Establishment
  (Dr. B.L. Lee, Co-Coordinator, Msc/Ms. Boram Lee, Secretariat)
- RDA : Ag-DB and Application Mirrors
  Simulation model Servers
  AgMet-Broker Provider
  Statistical Analysis Tools
  (Drs. S.H. Youn, W.S. Hahn)

Regional Associations

- APAN : Communication Network Administration Between Countries high speed backbone
  Other WGs : Information & Technology Advisory
  AG-WG : Technical Committee for RAMINS II

- AFFITA : IT and User application Provider
  at Regional level
  as National Delegates
  also responsible for domestic utilization
  Operational Management of Object Brokers
  Under the supervision by National Delegates
  Operation and Management Committee

International Organization affiliated

- FAO : Ag-Information Provider (Dr. Rene Gomez, Coordinator of AgMet. Group)
- WMO : Meteorological Information Provider(Dr. Sivakumar, Chief of AgMet. Division)
  (Dr. Ray Motha, President of CAgM, Dr. Kamali, RAII AgMet WG Chair)
- IRRI : Ag-Research Information Provider(?)
- Others : Ag-Oriented Information Provider, Technical Advisors

3.3. Tentative plans

So far it's been discussed on an individual basis; thus we could not secure the appropriate financial resources that will be a prerequisite for the successful establishment of this important network system for

Asian countries.

(1) Identification of Available Resources : Dec. 2003
- Database
- Tools
- Applications
- Facilities
- Networks
- Interfaces
- Experts
- Funds
- Others

(2) System Development : Dec. 2004
- Requirement Analysis
- System Architecture Analysis
- System Frame Design
- Data Archival
- Interface Development
- Operational Test

적 요

그리드는 고성능컴퓨팅을 위한 슈퍼인터넷이라는 신 IT기술로, 슈퍼컴, 저장매체, 첨단장비 및 협업환경 등 첨단 자원의 전세계에 걸친 가상집합체라 할 수 있다. 그리드는 CPU, 저장시스템, 통신시스템, 실시간자료원과 장비는 물론 공동협력 등 지역적, 기관간 분산되어 있는 전산자원을 한 곳에 모을 수 있을 것으로 기대된다. 그리드라는 말은 90년대 중반 첨단 과학 및 공학기술을 위한 분산전산하부구조로서 제안된 용어이다. 전산그리드는 사용자가 다수의 고성능/고정밀 자원을 접속/통합할 수 있도록 지원하는 하부구조를 의미하며, 보다 공적으로는 그리드는 개인, 기관 및 자원의 동적 집합체간 가상기구로서, 유연하고, 안전하며 조정이 가능한 자원공유를 위한 하부구조라 정의되고 있다. 이와 같이 그리드는 미래 농업기상서비스에 적합한 차세대 인터넷기술로 매우 유망한 IT기술인 것이다. 그리드는 특히 전산자원 부족이 심각한 개도국의 농업기상서비스 개선을 위해 필수적인 고성능 컴퓨터자원, 고용량 가상저장매체, 효율적인 실시간 자료교환,을 위한 자원공유에 크게 기여할 수 있을 것이다. 여기서는 WMO 차세대 기상정보시스템(FWIS)의 일환으로 기존 아시아 농업기상정보망과 연계된 CAgM-Grid의 설립을 제안 추진하고 있다.

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