A Grid for Efficient Decision Support in Agriculture

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EcoGrid: Fushan

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Examples of Agricultural decisions

- **Strategic**
  - Which crop or variety to plant
  - Whether to dam a river
  - What land use is appropriate

- **Operational**
  - Whether to spray a crop to protect from disease
  - When to harvest
  - How much to irrigate
  - Where will flooding occur?
# Potential for Data Sharing Between DSS

<table>
<thead>
<tr>
<th>Decisions</th>
<th>Weather Data</th>
<th>Crop details</th>
<th>Soils</th>
<th>Topography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety selection</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>To dam?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>App. land use</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Spray for disease</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Irrigate or not</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Manage flooding</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>
Agricultural Data Characteristics I

Data is common to all
or
Farm-specific

Dynamic

Chemical properties
Spray records
Weather

Multiple sources
Existing databases
Agricultural Data Characteristics

- Small scale, site-specific, various and distributed
- Heterogeneous similar databases
- Managed by several different ownerships
  - .gov .edu .com .org .net farm-level
- Difficulty of centralization
- Necessity of integration of various DBs to make decision
- Difficulty of commercial competition

Best match to Grid
Current Situation: Web-based applications but...

- Applications closely coupled to databases
- Limited range of applications at each site
- Duplicated development at each site
For example...

- e.g. Pest Management System
  - Identification of Pest and Guidance on Pest Management

Pest Illustrated Reference

Pesticide Information

Pest Management System

Pest Management Guide
What we want is Virtual Integration
Concept of Agricultural Grid

Neural Network

Growth Model 1

Weather Data 1

Field Data Monitoring

The Internet

Farm Management

Regression Model

Meta Database

Data Broker

User who needs Decision

Weather Data 2

Growth Model 2
It brings

• Maximize data and application usage without centralization
• Easy Maintenance
  – Easy updates of data and applications
  – Easy addition of new data and applications
• Flexible and dynamic integration of data and applications
Challenges

• Databases differ in format and structure (even if contain the same kind of data)
• Internationalization is time consuming
• Collecting and maintaining farm-level data is time consuming
Problem 1

• Databases containing the same kind of data (e.g., weather) differ:
  – Logical structure
  – Database software
  – Access method
DB heterogeneity causes

- e.g. Meteorological Databases

Growth Predictions Model

Pesticide Prediction Model

Heterogeneous Databases

Very low efficiency of database use and application development
Mediated Architecture – “Brokers”

- Consistent data access to one kind of data
- “Driver” for each database

Applications

Broker

Domain Databases (Heterogeneous)

- Relational
- File-based
- Web-pages/CGI
Data Broker brings

- e.g. Meteorological Databases
  - Meteorological Databases
  - Heterogeneous Databases
  - Meta DB
  - MetBroker
  - Growth Prediction Model
  - Disease Prediction Model
  - Farm Management Model
  - New plug-in for new DB
  - Weather DB A
  - Weather DB B
  - Weather DB C
  - Weather DB D

Do not need to modify applications for new weather DB

Very high efficiency of database use and application development
Broker Concept

- Case Base
- Farm Management
- Soil Data
- Meta Database
- Data Broker
- User who needs Decision

- Growth Model 1
- Weather Data 1
- Field Data Monitoring
- Weather Data 2
- Growth Model 2

The Internet
We Have Brokers For:

- MetBroker
  - Surface Weather Observations
- DEMBroker
  - Digital Elevation Models
- ChizuBroker
  - Web-based map services
- SoilBroker
  - Soils data
NARC Brokers

- Provide access to both password-protected and publicly accessible databases
- Utilize whatever access approach database owners are willing and able to provide
- Java applications access broker via RMI (have alternative HTTP firewall bypass)
- Have associated JavaBean components to simplify client application development (access each broker in a separate thread)
- Are open source under GNU LGPL
MetBroker

- MetBroker provides consistent access to heterogeneous databases
  - 15 databases (6000 stations)

- Functions
  - Metadata
  - Data requests
  - Query results
  - Proxy for authentication

- Access by Client
  - JavaRMI access for Java applications
  - SOAP-based access for
    - Visual Basic, Delphi...applications
Databases currently accessed:

<table>
<thead>
<tr>
<th>Database Name</th>
<th>St.No.</th>
<th>DBMS</th>
<th>Frequency</th>
<th>URL</th>
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<tbody>
<tr>
<td>New Zealand National Climate Database</td>
<td>6545</td>
<td>Oracle</td>
<td>10 min-1month</td>
<td><a href="http://www.kishou.go.jp">www.kishou.go.jp</a></td>
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<tr>
<td>AMeDas of JMA at MAFFIN</td>
<td>1479</td>
<td>Oracle</td>
<td>1hr-1day</td>
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<td>PostgreSQ</td>
<td>1hr</td>
<td><a href="http://www.wakayama.go.jp">www.wakayama.go.jp</a></td>
</tr>
<tr>
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<td>60</td>
<td>MySQL</td>
<td>15min-1hr</td>
<td>index.prosser.wsu.edu</td>
</tr>
<tr>
<td>Planteforsk, Norwegian Crop Research Inst.</td>
<td>33</td>
<td>MySQL</td>
<td>1hr-1day</td>
<td><a href="http://www.planteforsk.no">www.planteforsk.no</a></td>
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<tr>
<td>Florida Automated Weather Network (FAWN)</td>
<td>18</td>
<td>SQL Serve</td>
<td>15min</td>
<td>fawn.ifas.ufl.edu</td>
</tr>
<tr>
<td>South African Sugar Association</td>
<td>13</td>
<td>File-based</td>
<td>1day</td>
<td><a href="http://www.sasa.org.za">www.sasa.org.za</a></td>
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<td>Seoul National University DB</td>
<td>11</td>
<td>MiniSQL</td>
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<td>epilab.snu.ac.kr</td>
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<td>Horticulture Research International, U.K.</td>
<td>2</td>
<td>Oracle</td>
<td>1day</td>
<td></td>
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<td>1</td>
<td>PostgreSQ</td>
<td>1hr</td>
<td>riss.narc.affrc.go.jp/weathe r/chibacamp.asp</td>
</tr>
<tr>
<td>Tottori Hot. Exp. Stn. MAMEDA-DB</td>
<td>1</td>
<td>PostgreSQ</td>
<td>1hr</td>
<td>riss.narc.affrc.go.jp/weathe r/tottori.asp</td>
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PRAGMA Ecoinformatics Project

A Web Services Architecture for Ecological and Agricultural Data

Collaboration between SDSC, NPACI, the LTER Network, PRAGMA, APAN, NCHC

Scalable and extensible approach to integrated data management and analysis for computational ecology

Current prototype links the SDSC Spatial Data Workbench (sdw.sdsc.edu) with MetBroker system (www.agmodel.net/MetBroker) at Japan National Agricultural Research Center (NARC)

Prototype working with NCHC/TERN

• Developing additional Asian partnerships

Source: Tony Fountain, Longjiang Ding
MetBroker; Metadata

• For each database
  – list of stations
    • name, location, period of operation
    • data catalog (element x frequency
  – list of regions

• Client receives text in their own character set/encoding if possible
MetBroker; Data requests

- Period (eg Jan 1 1970 - Dec 31 1999)
- Elements (eg air temp, rain, radiation, wind)
- Resolution (eg hourly, daily)
- Control flags (eg allow summarising)
- Which stations
  - database & station id, or latitude longitude box
- Encapsulated in a single object
Query results - single station

- Station details and data sequences are encapsulated in a single result object.
Query results - multiple stations

- Request for a latitude longitude box
- Results from multiple weather databases for the requested area at once
Spatial Query

Client

Broker

- Temperature
- Rainfall
- Radiation
Handling Spatial Requests

Meta Data 1

Meta Data 2

DB 1

DB 2
Easy addition of a new database

• No change nor wrapper on database side at all
• A new plug-in development for MetBroker
  – OOP accelerates the process
  – Classification based on former experiences
  – Utilization of formerly developed objects
• It takes from a few hours to a few days, depending on how new a target database is
  – Time to analyze structure
Crop model applets with MetBroker

- Rice growth model
- Disease prediction model
- Pear growth model
MetBroker SOAP Interface; MetSOAP

Visual Basic client application

Delphi client application

Demo
ChizuBroker – Online Maps

www.mapfan.com (Japan)

www.mapzone.co.nz (New Zealand)
MetBroker+ChizuBroker

- An application to display weather data on map

Wakayama Prefec. Data & Amedas, Seoul University Data

ChizuBroker
Map Database

MetBroker
Weather Database
DEMBroker – Digital Elevation Data

World 1km resolution

Note that accessing the Japan data set takes much longer than accessing the world data set (because it is stored in many small files), so it pays to zoom into a small area of Japan before switching.

Japan 50m resolution

If possible, the applet retrieves data at a high enough resolution that each pixel has a unique value.

In most cases this means that you get a uniform sampling of the DEM. If you zoom in close, the underlying resolution of the DEM becomes apparent.

DEMBroker doesn’t do any interpolation of the data set at this stage — it retrieves the nearest DEM value to the location corresponding to the screen pixels.

Click to return to the DEMBroker home page.
DEMBroker+ChizuBroker
• Weather Risk Applet
• Meshed Prediction by Interpolation with DEM
Problem 2

- Commonly sharable data and applications among Asian countries with similar background of agriculture
- Need to be able to localize software to avoid duplication
- Great culture in languages
AG (agriculture) Grid

Info-Broker

Multi-Lingual
- Ontology
- Translation system
- Dictionary/Thesaurus

Diversity: Language/Character/Culture
Different: Structure/Data set/DB system

Sharing
Java ResourceBundle Issues

- Maintenance:
  - Add new item → must recompile
- Performance:
  - Not designed for distributed computing
- Java-specific
Translator Applet

A screen capture of the Translator Applet interface, showing a table with translations for various units and terms.
Problem 3

• Collecting and Maintaining Farm-level data
Efficient Data Acquisition

e.g. Growth Model
Field Monitoring Server
Fieldserver Roles

- Field monitoring (weather, camera)
- Wireless Internet access point (for PCs, wearable computers...)
- Wireless relay
- Autonomic by solar batteries
- Ubiquitous rural area
Filed Monitoring Server with Wireless LAN

- Weather station
- Greenhouse
- SOHO
- Mountain
- Internet provider
- Giga-bit network
- CATV
- home/office

Diagram showing connections between various locations and facilities such as weather stations, greenhouses, and SOHO, indicating a network setup with wireless LAN capabilities.
On-Site Data Input by Mobile Phone

Mobile Phone with Web browser and e-Mail
Summary

• Grid based decision support
  – handles the diverse kinds of data, databases and client applications prevalent in agricultural domain
  – accelerates efficiency of system development and maintenance
  – eliminates the duplication of distributed resources,
  – reduces time and cost.

• Such benefits are really important and desirable for such a sector as agriculture where research investment is static or shrinking
Asian Collaboration
With Asian Agricultural Grid

Cambodia Ag-Field

Field Monitoring
Optimized Pest Management

End User

Pest Prediction
Cambodian

Machine Translator
NECTEC

Data Broker

APAN

Earth Monitoring Satellite

MAFFIN Japan

SIDaB

Image Analysis

Result of Analysis

NARC

Pest Prediction Model
Japanese

Field Data

Satellite Image

Internet Satellite
Thank you for your attention

http://www.agmodel.net
http://yummy.narc.affrc.go.jp
http://agrinfo.narc.affrc.go.jp