



行政院環境保護署

Environmental Protection Administration
Executive Yuan, R.O.C. (Taiwan)

A Multi-layered System Architecture for Environmental Monitoring Data Management Taiwan's Experience

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Introduction (1/2)



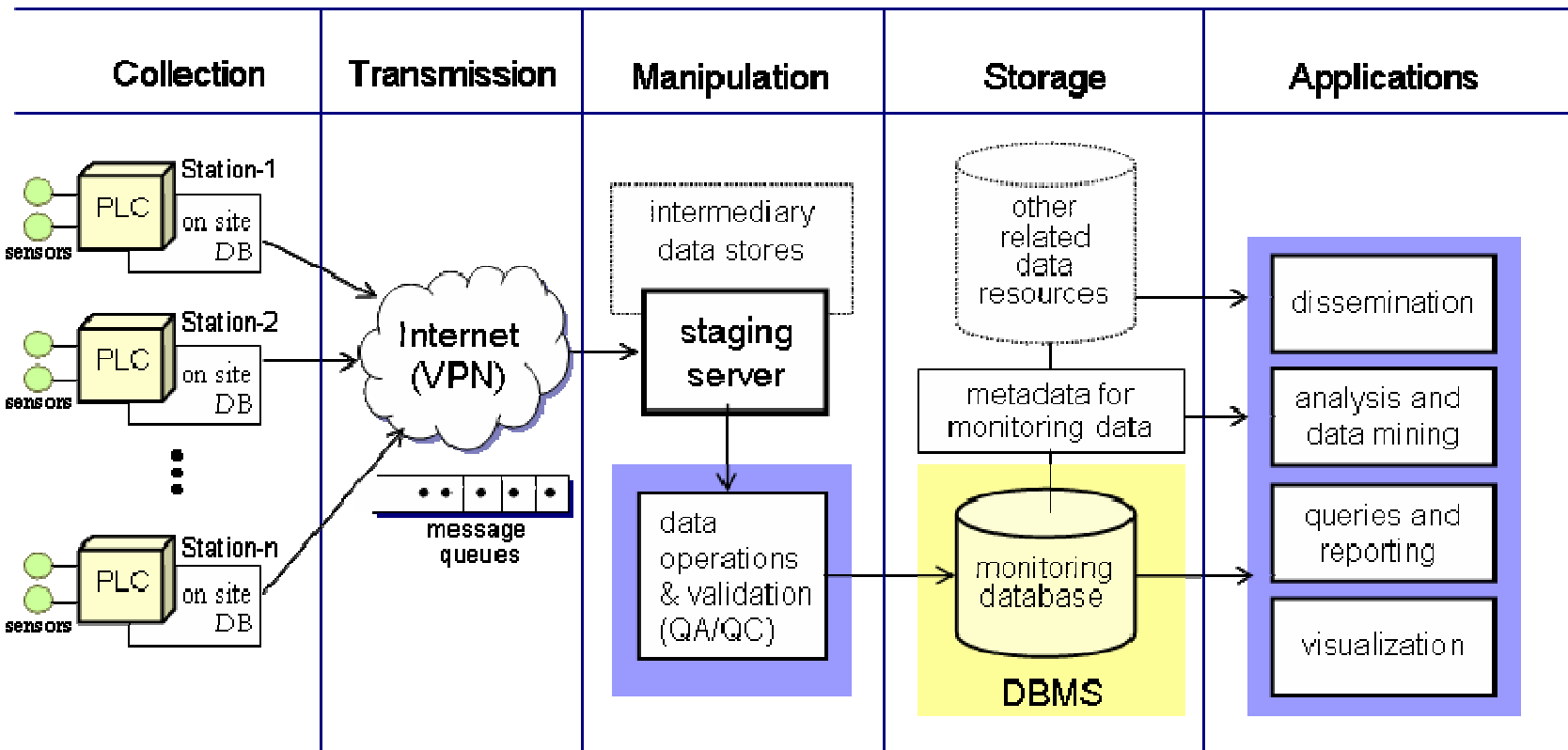
- Environmental monitoring data plays an important role in supporting environmental decision-making
- The task of environmental data management becomes ever more challenge
- We need a comprehensive and integrated system architecture that can **streamline** and consolidate the data management processes for environmental monitoring

Introduction (2/2)



- We present a system architecture
 - using multi-layer approach
 - based on the web-based platform
 - ranging from data collection to applications
 - purpose: **streamlining of data management processes for environmental monitoring**
- Taiwan Air Quality Monitoring Network (TAQMN-2) has been implemented using the proposed system architecture

System Architecture (1/6)



System Architecture (2/6)



- **Collection layer**

- comprises a number of apparatuses connecting to a programmable logic controller (PLC), forming the front line for data collection and gathering
- an on-site database dedicated to storing these data, converting them into XML format
- adopts a series of **open standards** such as HTTP and TCP/IP for connecting monitoring apparatuses and IT devices

System Architecture (3/6)



- **Transmission layer**

- apply virtual private network (VPN) technology which integrates with the comprehensive firewall and router features

It supports connection for a **secure data transmission** over the Internet

- use Microsoft Message Queuing (MSMQ) technology as a data transmission platform that bridges the collection layer and manipulation layer

System Architecture (4/6)



- **Manipulation layer**

- When data is gathered from the monitoring sites, it moves through the **staging server** along with an intermediary store
- In this area, we examine collected data, perform the various functions for **data quality assurance** and resolve inconsistencies
- Once the data is finally prepared, it will temporarily reside in the intermediary data stores waiting to be loaded into the monitoring database

System Architecture (5/6)



- **Storage layer**

- consists of a commercial database management system (DBMS) along with a set of toolkits to maintain the metadata for monitoring data
- in order to provide data services more efficiently and widely, this layer may also aggregate data and functionalities from other sources such as the meteorological offices which may provide data on environmental resources in particular weather forecast information

System Architecture (6/6)



- **Application layer**

- provides a number of applications and services for data retrieval, analysis, as well as data dissemination
- a variety of advanced applications such as data mining and data visualization can also be attached as part of the systems
- The user interface for most applications uses Web standards: XHTML and CSS are used for presentation; JavaScript and ASP.NET are used to handle user interaction



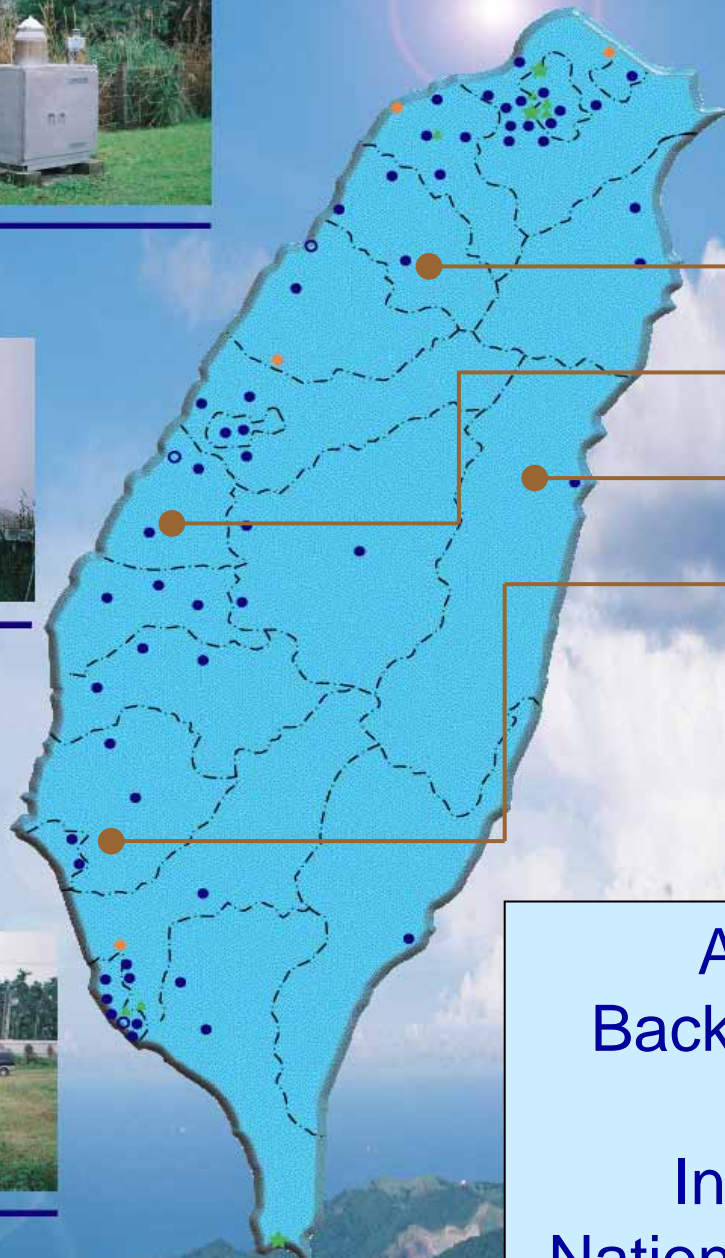
TAIWAN

- Located in the Western Pacific about 160 km off China's southeast coast, midway between Japan and the Philippines
- An area of approximately 36,000 sq. km (about 394 km long and 144 km wide)
- Total population around 23 million people (average density 621 person/km²)

TAQMN-2 Project (1/5)



- Taiwan Air Quality Monitoring Network
- an automated and computer aided air quality monitoring system
- Established in 1993 with 66 stations, 2 mobile vans equipped with monitoring facilities, 1 QA/QC Lab
- Expanded to 76 stations and 6 mobile vans in 2006



monitoring stations
in various locations

Northern 25

Central 18

Eastern 4

Southern 26

73

Offshore Islands 3

Ambient - 58

Background - 3

Traffic - 7

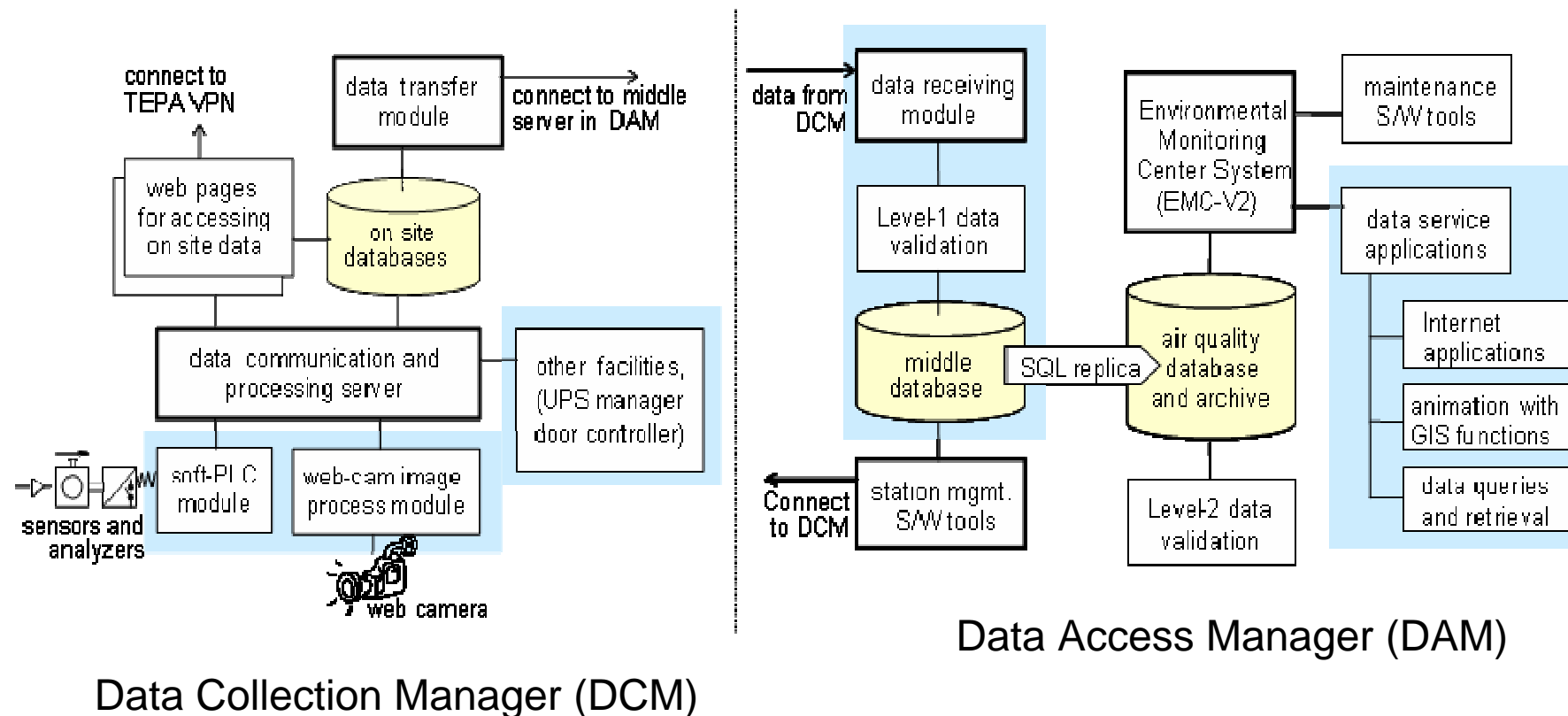
Industrial - 4

National Park - 4

TAQMN-2 Project (2/5)



- Overall structures



TAQMN-2 Project (3/5)



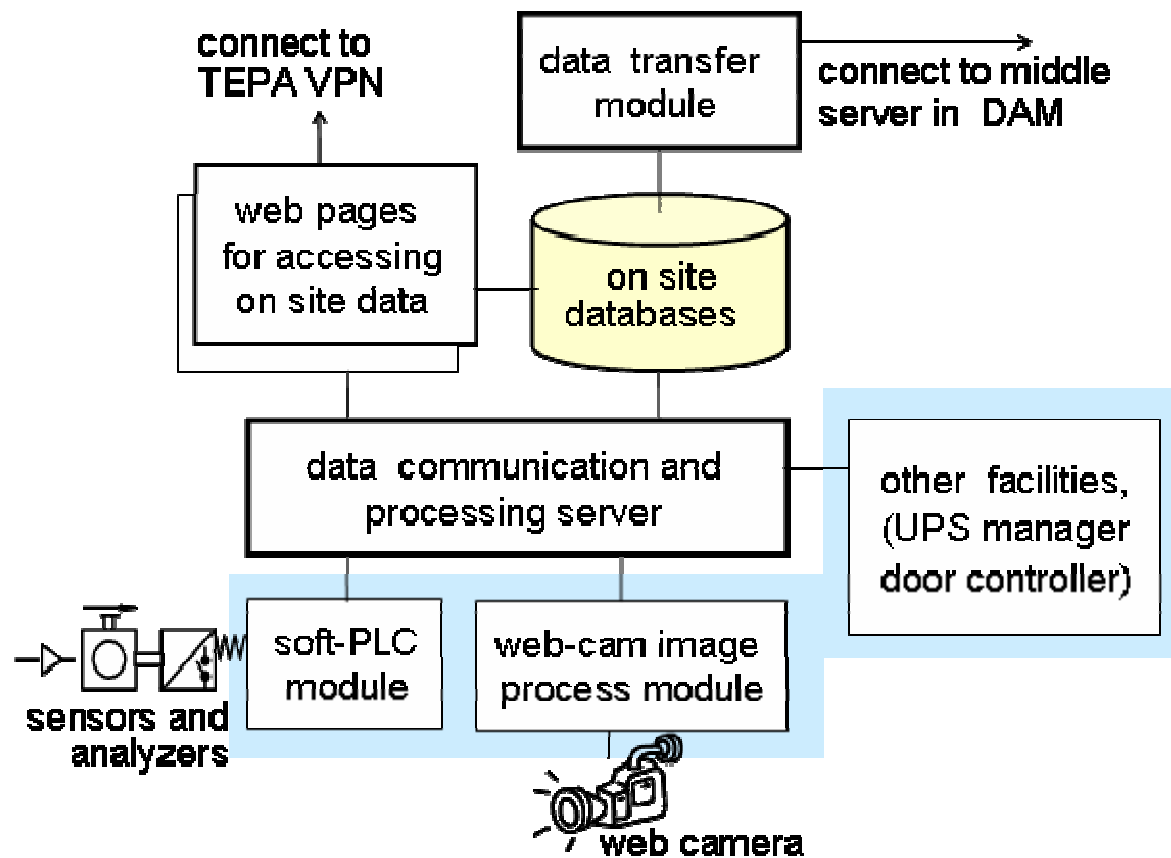
- Implementation environment

	Data collection manger (DCM)		Data access manager (DAM)	
	gathering and collecting	communication and processing	middle server	database server
H/W	Soft-PLC	Xeon (DP) 2.4GHZ	Xeon MP 1.5GHZ	HP RX-5670 HP MSA-1000
OS	Build-in Kernel	Win2000 Server	Win2000 Server	Win2000 Server
Data storage	Text Files	Oracle 9i DMBS	Oracle 9i DMBS	Oracle 9i DMBS
Development tools	Ladder, Java and C language	MS .Net and Java language	MS .Net, Java and SQL	MS .Net, Java and SQL

TAQMN-2 Project (4/5)



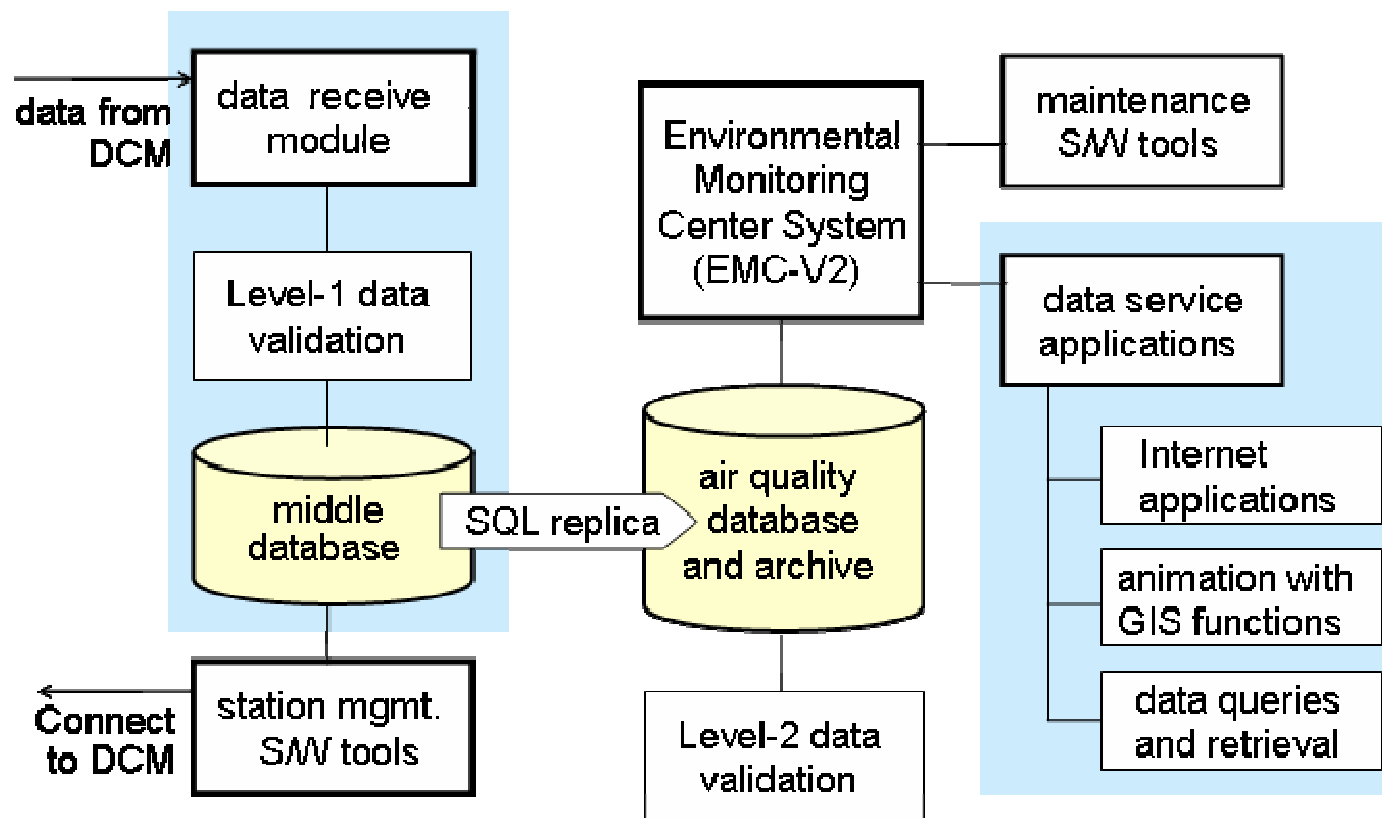
- data collection manager (DCM)



TAQMN-2 Project (5/5)



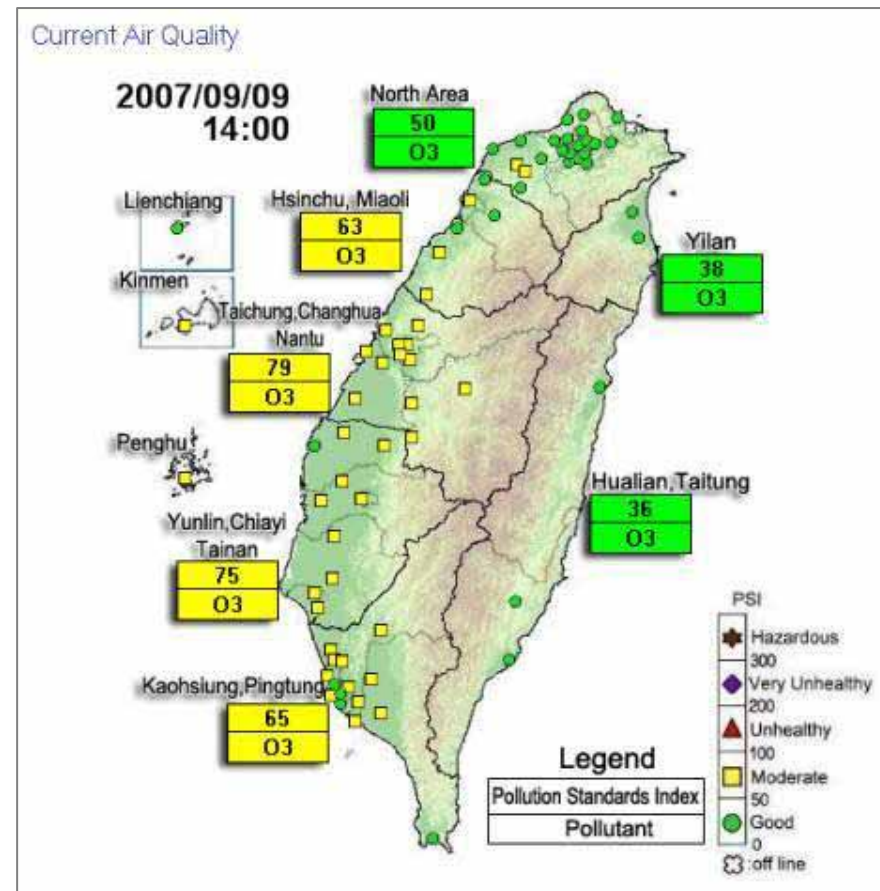
- data access manager



Results and lesson learned



- The country map displays the current PSI value of each region
- The data is updated hourly
- Users can select a region to view detailed data



<http://210.69.101.141/emce>



- When the region of Yunlin-Chiayi-Tainan is selected for viewing, all detailed measurements of the stations in the region are displayed

Home > Air Quality Monitoring Network

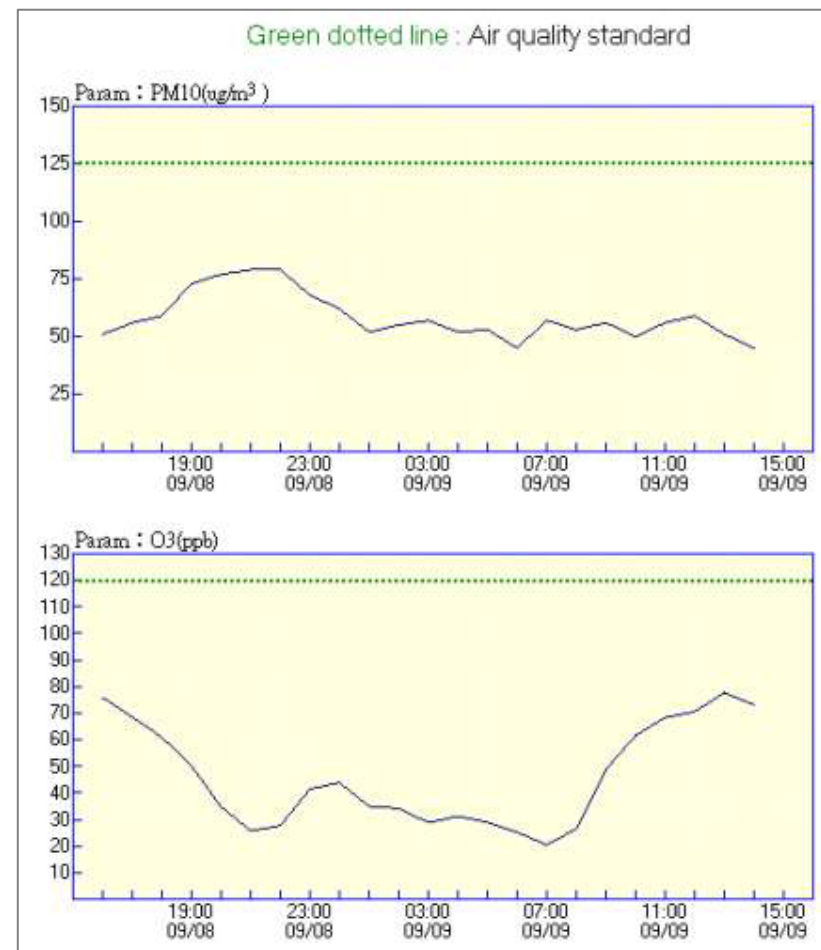
Yunlin, Chiayi, Tainan Area PSI

Air Quality: Moderate, PSI: 75

SITE	PSI	SO ₂		CO		O ₃		PM ₁₀		NO ₂	
		sub-index	value (ppb)	sub-index	value (ppm)	sub-index	value (ppb)	sub-index	value (ug/m ³)	sub-index	value (ppb)
Douliou	65	6	4	5	0.46	65	78	54	58		10
Lunbei	74	7	4	5	0.42	74	89	62	75		11
Singang	56	5	3	4	0.40	52	63	56	62		10
Puzih	58	7	4	5	0.41	56	67	58	65		12
Chiayi	51	6	3	5	0.45	51	61	51	52		11
Sinying	64	6	4	5	0.45	64	77	58	67		10
Shanhua	69	6	4	4	0.32	69	83	52	55		9
Annan	54	6	3	5	0.48	44	53	54	58		20
Tainan	81	8	5	6	0.53	81	97	51	52		26
Region	75	7	4	5	0.49	75	90	59	69		19



- When user selects a specific monitoring station, the past 24 hours of data will be displayed using a Java-based graphic interface, measurements of the stations in the region are displayed

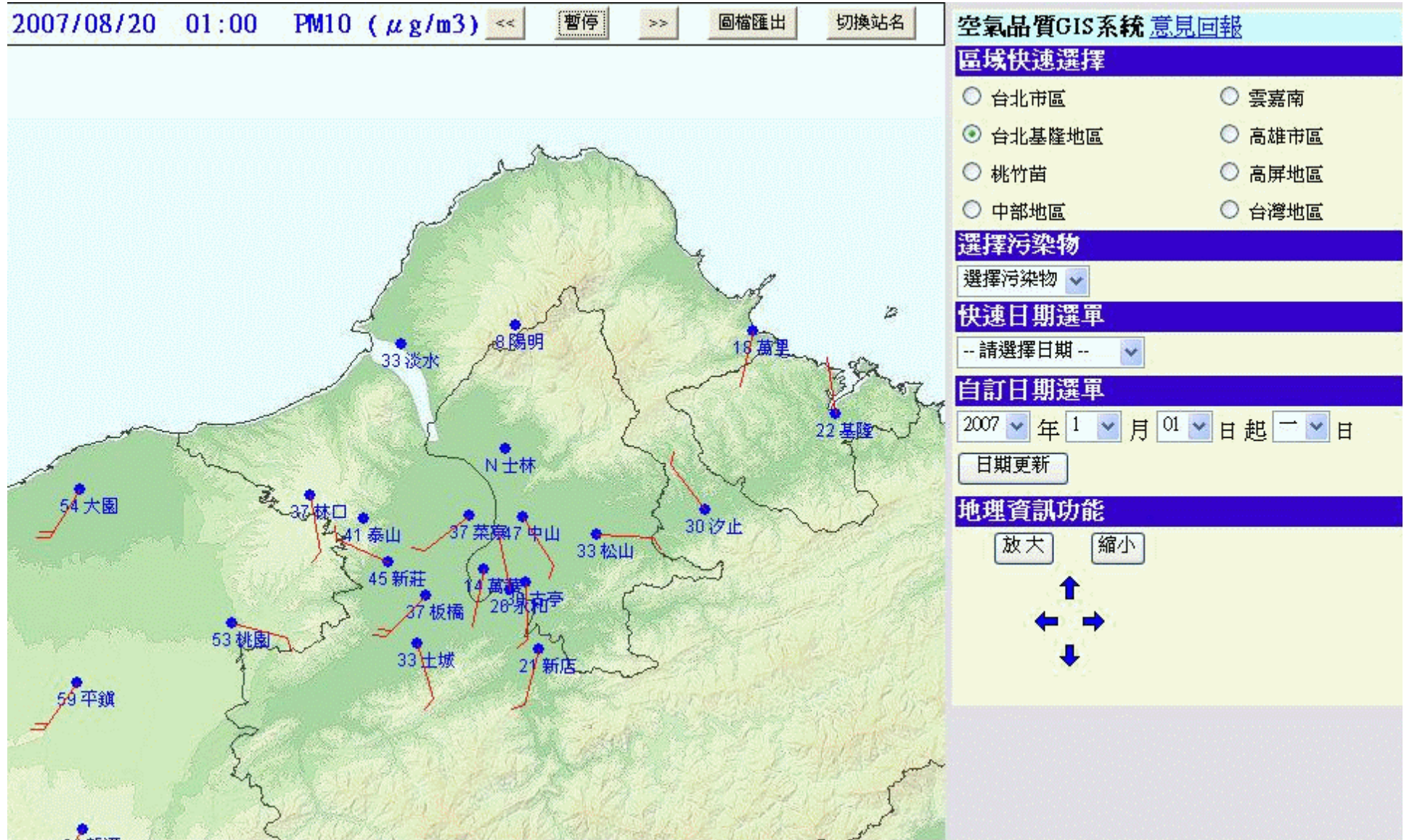




- the location of each station and the images for the surrounding status can also be displayed using a GIS-based toolkit



● GIS with wind speed and wind direction





- **An interface for data access**

- data can be aggregated over time, either by specifying a defined period or by using time related grouping functions such as monthly, weekly and so on
- data can be selected or filtered according to a specified condition (measured value, time period, as well as certain areas and districts)



Conclusions



- The main advantages:
 - replaces conventional data acquisition system (**DAS**) with an open standards web-based server attached with a PLC system making monitoring work more flexible
 - provides a platform for automatically tracking data lineage while monitoring workflow execution
 - supports tasks to systematically collect diverse monitoring data
 - requires minimal modifications to migrate existing monitoring systems
 - improves the scalability of environmental monitoring projects, in terms of both ease of adding and modifying components in each layer

Future work



- adopt XML and related technologies such as Web Services, SOAP, and UDDI, based on the concept of multi-layer architecture, to construct a **loosely couple platform** for integrating heterogeneous environmental monitoring data
- some of the data mining methods are considered to be associated with our platform for **shaping environmental data** to be more useful to support the environmental decision-making



Thank you!
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