

Web 2.0 for Radiologists: Open Source DICOM Clustering Servers and Web-based Viewer Using Asynchronous JavaScript and XML (AJAX)

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**We developed cluster web DICOM server
using Asynchronous JavaScript and
XML(AJAX).**

**We report on details of the development and
the real operation experience .**

Introduction

Web 2.0 is the term given to describe a second generation of the World Wide Web that is focused on the ability for people to collaborate and share information online. Web 2.0 basically refers to the transition from static HTML Web pages to a more dynamic Web that is more organized and is based on serving Web applications to users. Other improved functionality of Web 2.0 includes open communication with an emphasis on Web-based communities of users, and more open sharing of information. Over time Web 2.0 has been used more as a marketing term than a computer-science-based term. Blogs, wikis, and Web services are all seen as components of Web 2.0.

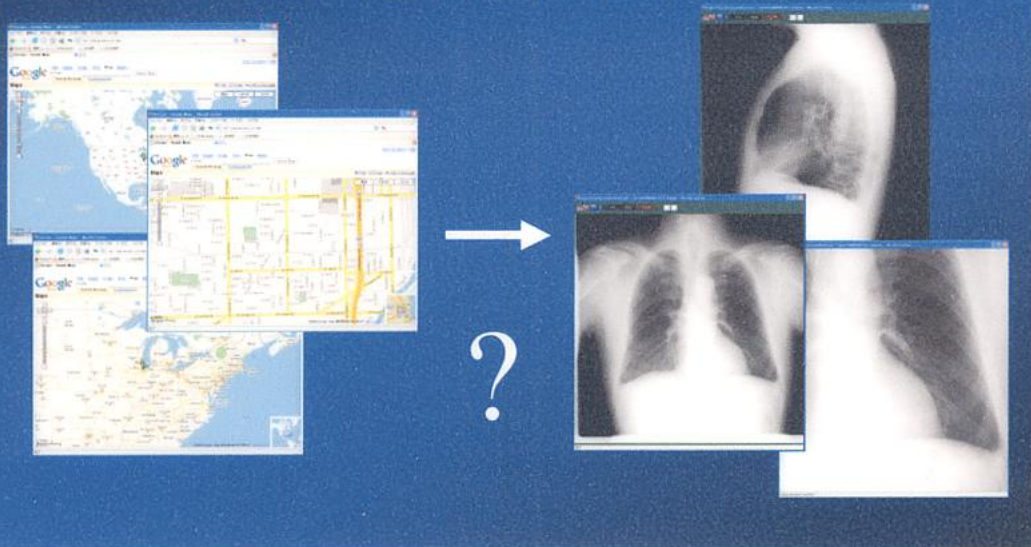
Web 2.0 was previously used as a synonym for Semantic Web, but while the two are similar, they do not share precisely the same meaning.

Web 2.0 is the term given to describe a second generation of the WWW that is focused on the ability for people to collaborate and share information online. Web 2.0 basically refers to the transition from static HTML Web pages to a more dynamic Web that is more organized and is based on serving Web applications to users.

because of the improvement of the function , Web2.0 has the possibility that an existing application can be substituted in a lot of scenes, and is paid to attention.

The good sample that web2.0 is google map. Google map is providing interactive service with excellent GUI in web browser. We were not able to find it like google map in radiological field though we looked for service of the image inspection and the report system.

Then, We wanted to make google map for radiologist. And, we thought whether it was able to be used effectively on an actual use.



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It is the following matters according to thesis "What is Web 2.0" of Mr. Tim O 'reilly known as a landlord of Web 2.0 that characterize Web 2.0.

1. The Web As Platform
2. Harnessing Collective Intelligence
3. Data is the Next Intel Inside
4. End of the Software Release Cycle
5. Lightweight Programming Models
6. Software Above the Level of a Single Device
7. Rich User Experiences

We interpreted these items and decided the development policy.

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Interpretation of web 2.0 requirements

- 1. The Web As Platform**
Consistency and efficiency might go up by patient list retrieval and inspecting the image with a single web browser.
 - 2. Harnessing Collective Intelligence and 3. Data is the Next Intel Inside**
The environment to which a radiological image and other image, etc. are integrated might be useful.
Moreover, it was thought that the value of information rose by linking the web resource such as google/google scholar/PubMed with the case.
 - 4. End of the Software Release Cycle and 5. Lightweight Programming Models**
If a lightweight language is used, a more flexible application might be able to be made. Moreover, it was thought that it contributed to customer's satisfaction and the quality of the system at the rapid development cycle with the user participation.
 - 6. Software Above the Level of a Single Device and 7. Rich User Experiences**
It was thought that the offer of the environment matched to user's style (for instance, mobile terminal etc.) expanded the usage.
It was thought that efficiency go up if web browser have high usability. Additionally, efficiency might be improved by cooperating immediately with DICOM viewer (for instance, Osirix etc.). So-called MashUp.
- MashUp : MashUp is to combine two or more different technology and contents. Two or more API is combined, synergy effect was formed.

Development policy of the system

- The Web As Platform**
Development of system (web server/client system) that can do list extraction/image inspection only by web browser.
- Harnessing Collective Intelligence and Data is the Next Intel Inside**
A link with the web resource is positively taken.
Images of a lot of forms can be integrated by constructing the DICOMiser system.
- End of the Software Release Cycle and Lightweight Programming Models**
Quick development style with the user participation is done. A light language is used for that.
- Rich User Experiences**
Development of a useful function(dragging WL/WV change, image magnification etc.) with web browser.
Development of a seamless coordinated system with an external program.

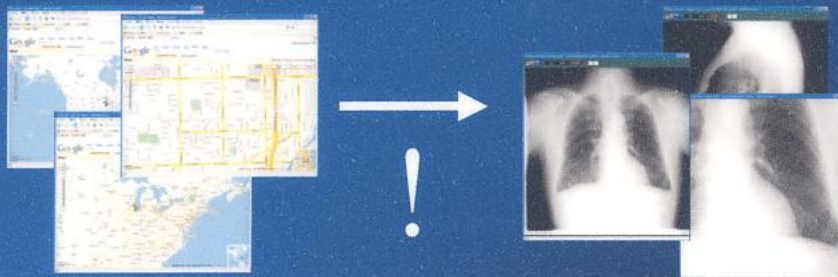
We examined each item, and decided the development policy.

Please refer to the poster for details.

Filling requirements of web2.0 , we tried the development of the PACS system like google maps.

We aimed at the system that have Correspondence to a large amount of processing demand and Stability/Reliability.

Additionally,we aimed construction of the system with open source.Because we are sympathizing with that idea.



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Purpose

- 1, We tried the construction of System that solved requirements of web2.0 .
 - 2, We tried this System having the Correspondence to a large amount of processing demand and Stability / Reliability.
 - 3, We tried those construction by open source collaboration , development itself as open source.
- And, we considered those feasibility and possibility.

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Method

There were some problems that had to be solved when the system was developed. We listed the item. And the selected method of settlement was listed.

List of problem that should be cleared.

1. How is the DICOM image preserved? Is only the file preserved? Is the data base used for related information? Which is used if the database is used? Which does the software of the DICOM communication use?
2. Which does web server/processing software corresponding to the demand of the client? Which technology is used for interactivity with the user?
3. How should we do to inspect the image by web browser that cannot inspect directly the DICOM image?
4. Which web browser of the client is good?
5. What technology do we use to obtain the Correspondence to a large amount of processing demand and Stability/Reliability?
6. Which of OS of the server is good?

Solution of problem that should be cleared.

1. How is the DICOM image preserved? Is only the file preserved? Is the data base used for related information? Which is used if the database is used? Which does the software of the DICOM communication use?
→ It was thought that the data base was necessary for a large amount of image storage and management. We requested the steadiness from high speed for the data base. We selected postgres. We selected CTN(central test node). CTN is DICOM server software of the open source that can synchronize with postgres.
2. Which does web server/processing software corresponding to the demand of the client? Which technology is used for interactivity with the user?
→ We selected apache as web server. We selected PHP as processing software. Because PHP is processing software that the manufacturing efficiency is high, and cooperation with the data base is good. We used AJAX for interactivity with the user. AJAX is excellent solution gives web browser interactivity with the server.
3. How should we do to inspect the image by web browser that cannot inspect the DICOM image directly?
→ We selected the method of conversion into the general-purpose image format which a browser can display. Because security falls by using the plug-in such as ActiveX and The communication flowing quantity can be decreased by using a general-purpose image. (Can use even be a narrow network.)
4. Which web browser of the client is good?
→ We thought that a high performance web browser in open source was necessary. We selected firefox.
5. What technology do we use to obtain the Correspondence to a large amount of processing demand and Stability/Reliability?
→ We selected the clustering technology. The reason for the clustering technology is that a high power system can be constructed at a low price by making cost good general-purpose computers cooperate.
6. Which of OS of the server is good?
→ We thought that linux was good as OS of the server.

Method

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Please refer to the poster for details.

Summary of Solutions

The backbone of servers

server OS : linux

web server : apache

database application : postgres

dicom server application : ctn

DICOM application : dcmtool, dicom3tools, xmedcon

client OS : any

client web browser : firefox

Lightweight Programming Models

Development language : PHP

Rich User Experiences

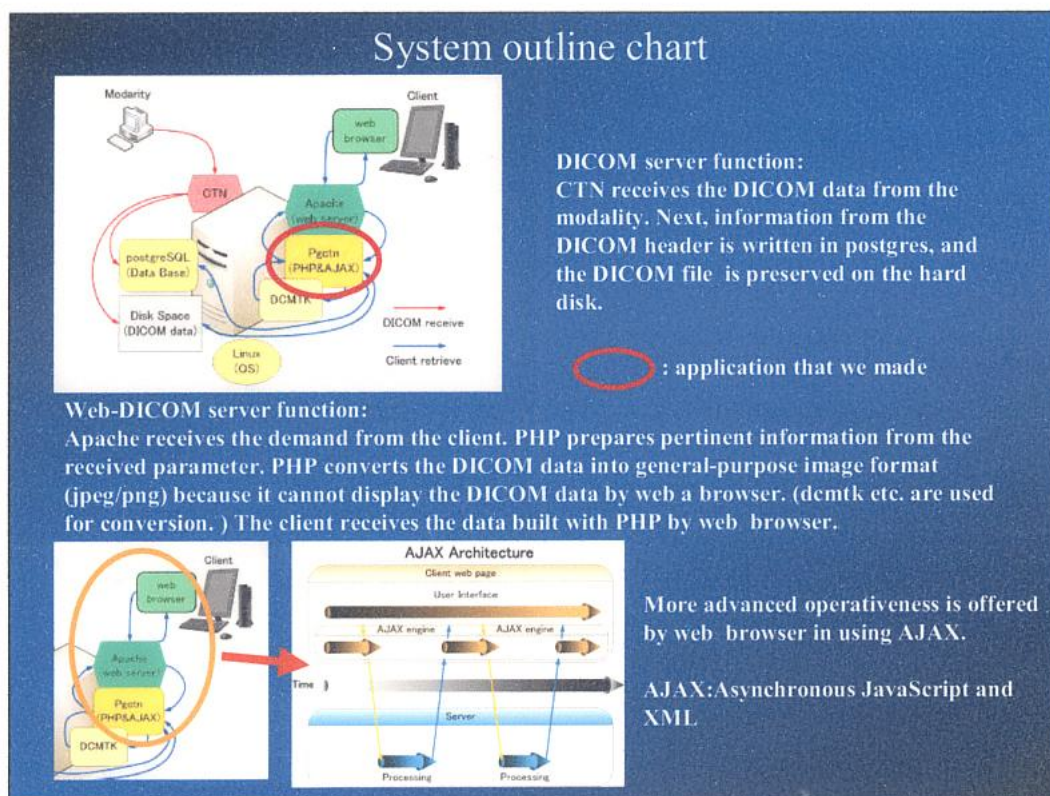
web browser level : AJAX(Asynchronous JavaScript and XML)

detail DICOM viewer : OsiriX(Mac OSX), UniPacs Viewer(windows)

Stability/Reliability

clustering technology:LVS,heartbeat

The list is Summary of Solutions .



This chart is System outline chart .

Figure explains the function of the DICOM server and the web server.

We requested interactive with a server that was more advanced than a past web application for the usability improvement.

We used the AJAX technology for that.

AJAX is a technology that exchanges real-time data transfer by the background among the server and users, and improves the usability.

This is one of the web2.0 technologies paid attention to.

clustering system outline chart

•What is clustering?

Two or more computers are connected mutually, its behave like the high power computer against the user and other computers. The entire system doesn't stop even if one stops, and the repair and the exchange can be done with processing continued. It seems only that the performance of the system fell from the outside the other day. Moreover, the improvement of the performance can be achieved only by increasing the number of the computer that connects it.

By the way, Google that is the most famous internet search engine in the world consists of the Linux cluster. Though the scale is very small, we constructed a similar system.

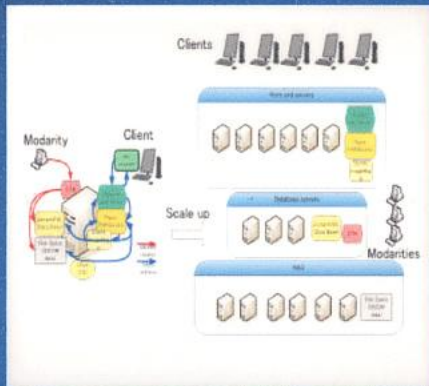
•Advantage of clustering

As a purpose to make the cluster

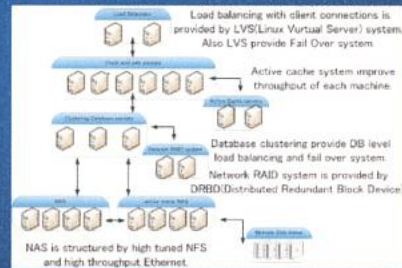
- 1 High-speed calculation processing
- 2 Correspondence to a large amount of processing demand
- 3 Stability and reliability

The above is used properly by the scene.
We requested the advantages of above 2,3.

Service can be provided for more users by using clustering. (For instance, to the whole in the hospital.) Additionally, the key section service can be provided by giving reliability.



We divided the system into database, data storage, web application layers. The server of the each layers provides service while mutually cooperating as a whole. The entire ability can be improved by adding the server if there is power shortage in which layer.



This chart is clustering system outline chart.

Clustering is the technology that two or more computers are connected mutually, its behave like the high power computer against the user and other computers .

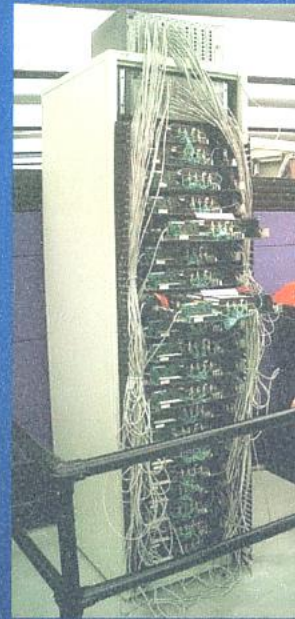
It make 1 High-speed calculation processing 2 Correspondence to a large amount of processing demand 3 Stability and reliability .

We requested the advantages of Correspondence to a large amount processing and Stability / reliability



This photograph is clustered servers that actually used.

By the way, this photograph is initial google server.



This photograph is clustered servers that actually used.

By the way, rt photograph is initial google server.

It is thought it is much the same.

Result

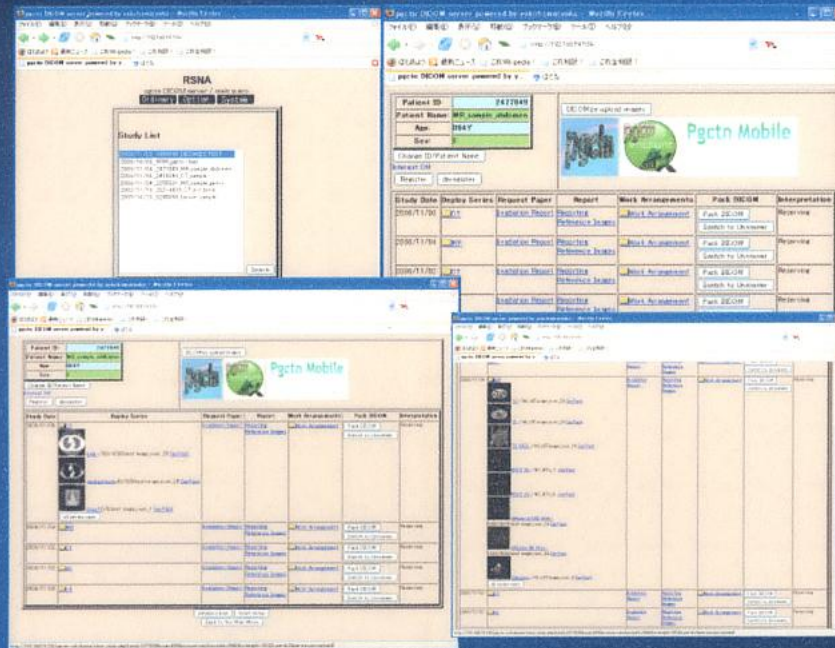
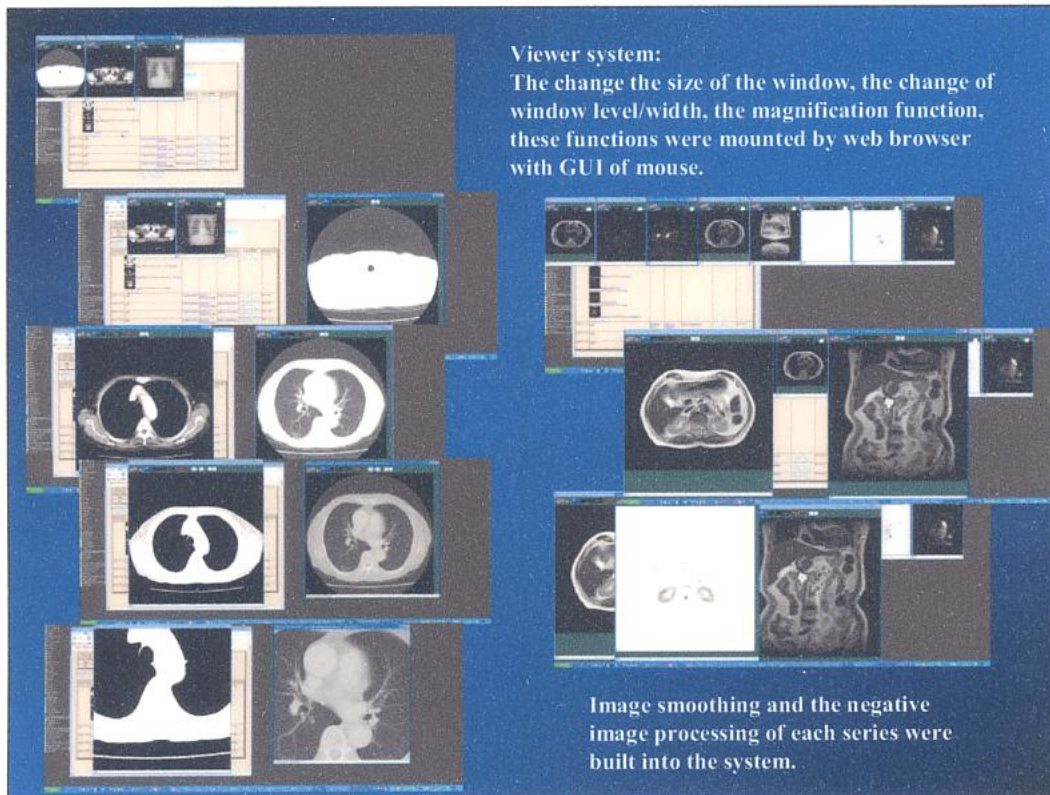


Figure on the main screen

Result

This is the main screen of the system.

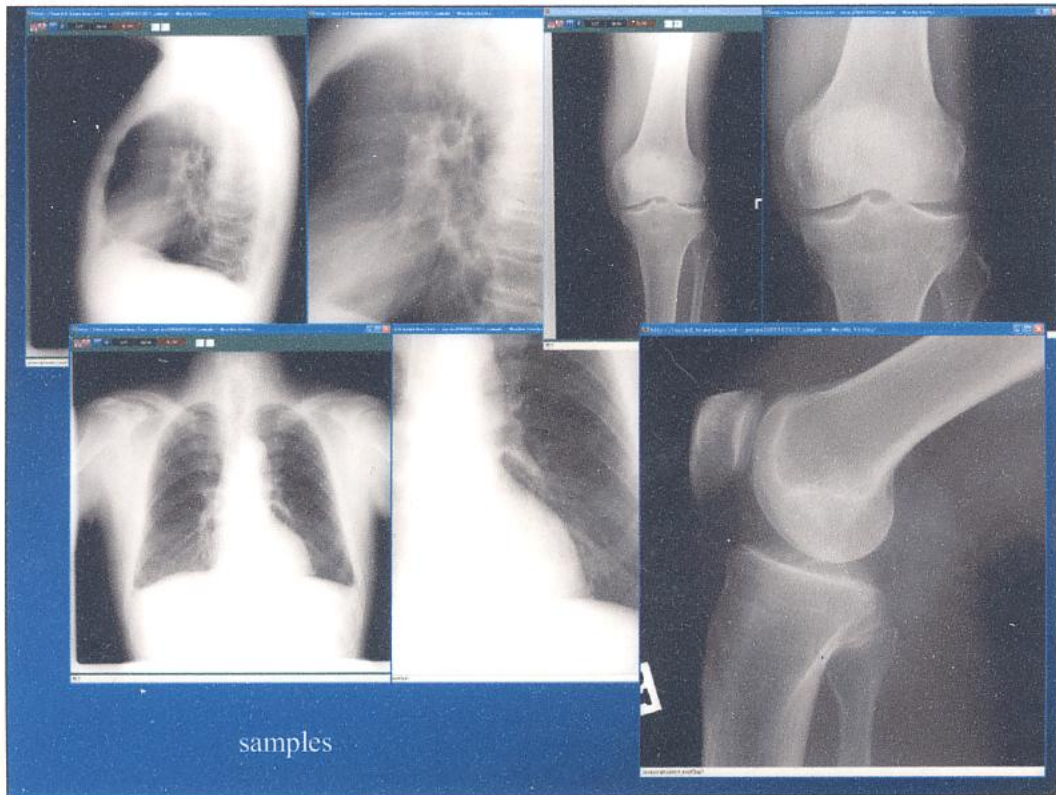
This is an entrance of the patient's selection and the thumbnail of the list and additional information.



Viewer system have the change the size of the window, the change of window level/width, the magnification function.

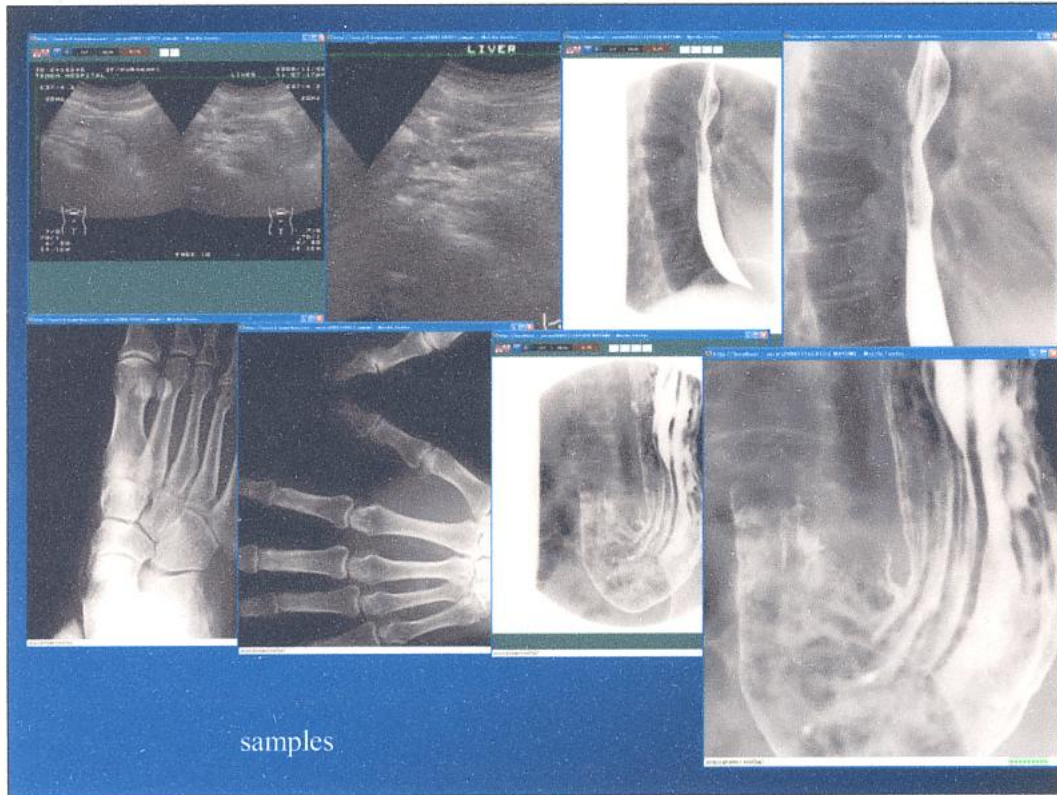
These functions were mounted by web browser with GUI of mouse.

Image smoothing and the negative image processing of each series were built into the system.

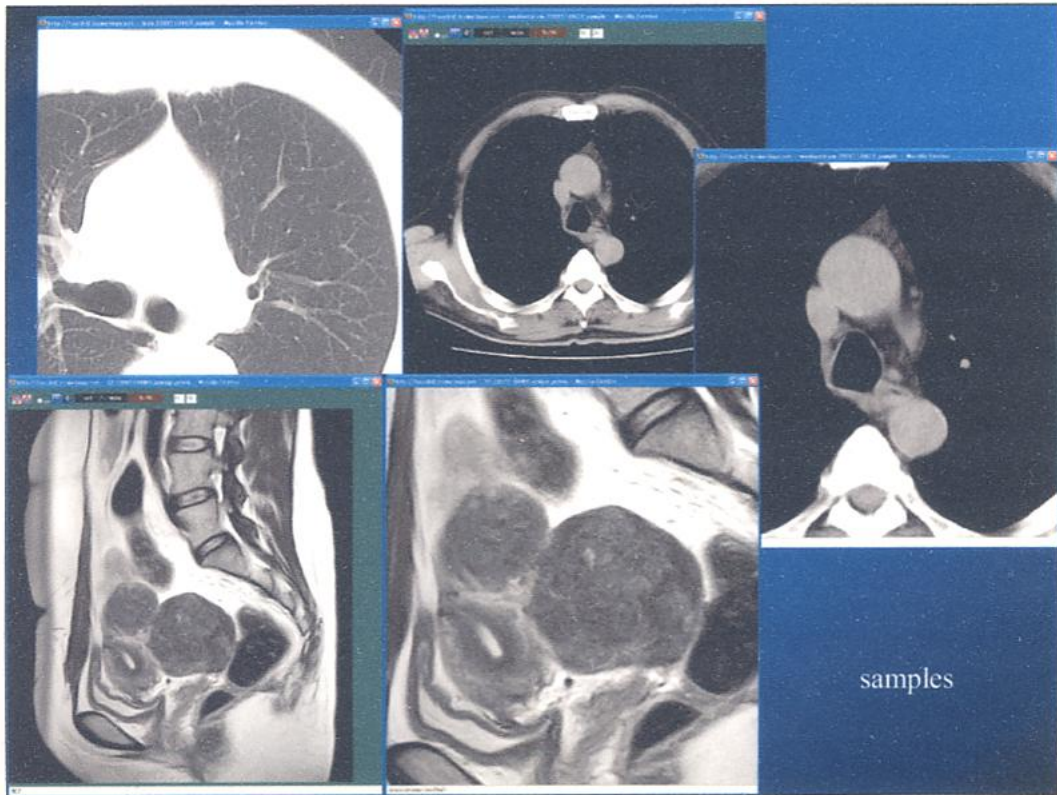


Some display samples will be presented.

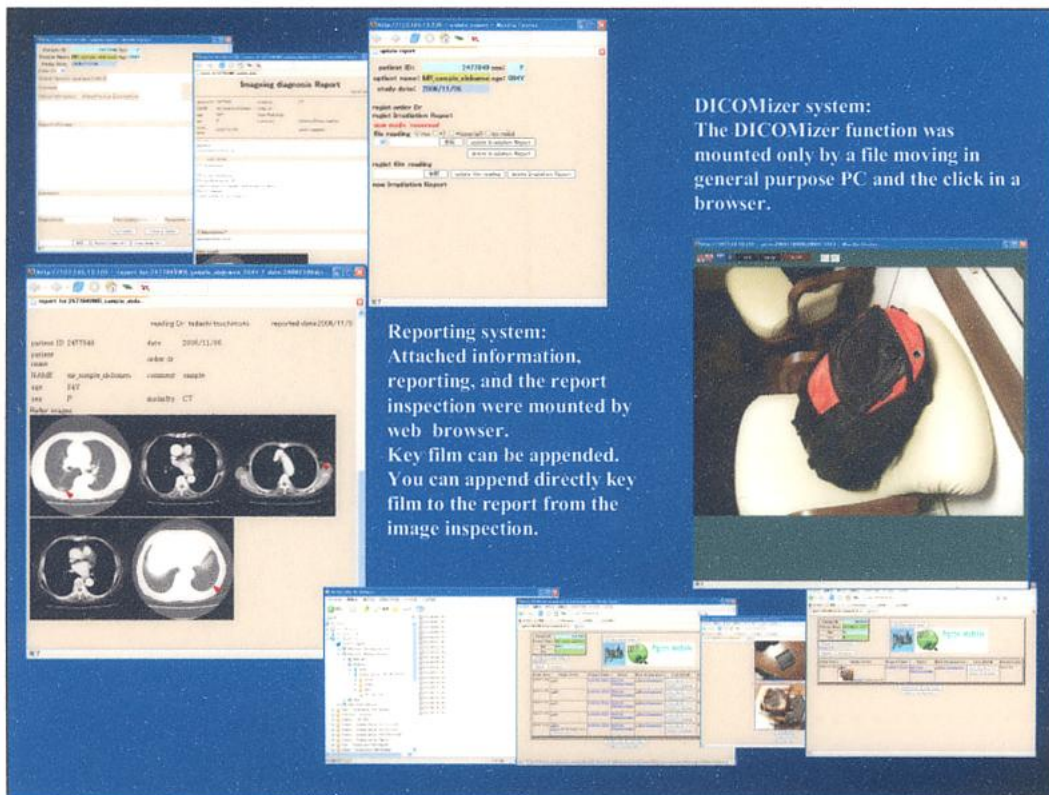
This is a chest plain and roentgenogram of the bone .



US images and roentgenogram of the bone and digestive enhancer inspection .



CT of the chest and MRI of the pelvis .



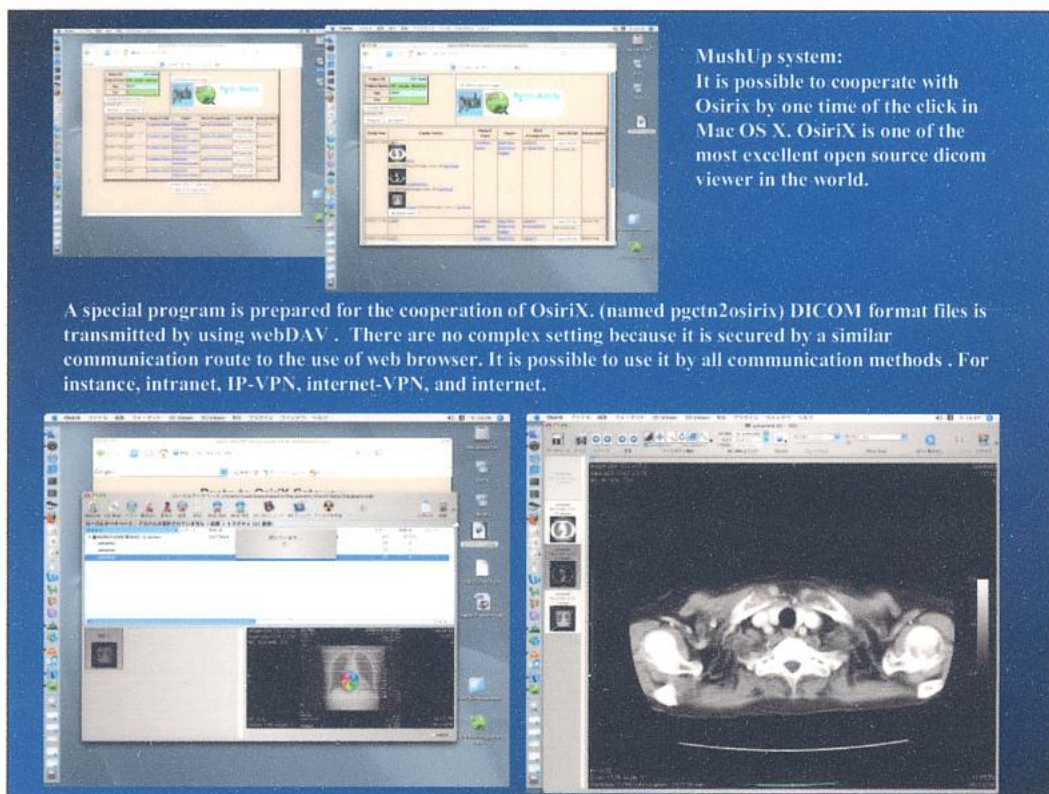
The system provides the report function at each study. Key film can be put directly from the image inspection.

To register information other than DICOM to the system positively, we applied the DICOMizer function.

Web resource system:
The system has a direct google search function. The retrieved useful web resource can be easily registered to the system.

The registered web resource can be referred to directly from the system. It is possible to link with the web resource in the seamless by the function of an original web browser. (It thinks the development to make the retrieval link by the automatic morphological analysis of the report in the future.)

The system has a direct google search function. The retrieved useful web resource can be easily registered to the system.



MushUp system:
 It is possible to cooperate with Osirix by one time of the click in Mac OS X. OsiriX is one of the most excellent open source dicom viewer in the world.

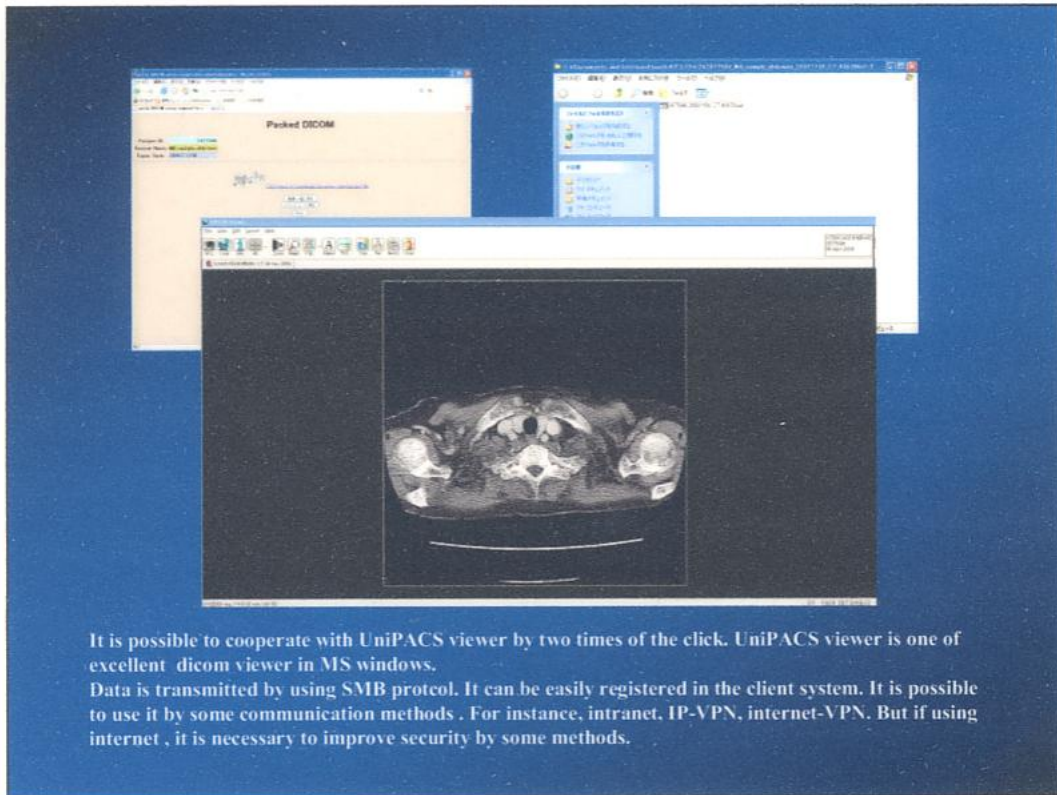
A special program is prepared for the cooperation of OsiriX. (named pgctn2osirix) DICOM format files is transmitted by using webDAV . There are no complex setting because it is secured by a similar communication route to the use of web browser. It is possible to use it by all communication methods . For instance, intranet, IP-VPN, internet-VPN, and internet.

In addition to the image inspection by web a browser , we made seamless cooperation with DICOM viewer for detail inspection .

We respected OsiriX, and we wanted to cooperate with OsiriX .

A special program is prepared for the cooperation of OsiriX. (named pgctn2osirix) DICOM format files is transmitted by using webDAV .

It is possible to use it by all communication methods . For instance, intranet, IP-VPN, internet-VPN, and internet.



It is possible to cooperate with UniPACS viewer by two times of the click. UniPACS viewer is one of excellent dicom viewer in MS windows.
Data is transmitted by using SMB protocol. It can be easily registered in the client system. It is possible to use it by some communication methods . For instance, intranet, IP-VPN, internet-VPN. But if using internet , it is necessary to improve security by some methods.

**In windows, to cooperate with DICOM viewer,
we made it.**

We tried real operating the application and server.
The agreement facilities were raised, and the adjustment of each facilities of the operation model was done repeatedly.
The main operation model was classified as follows.

- 1, Dept. Radiology use
- 2, The entire hospital PACS
- 3, Telediagnosis
- 4, Diagnosis support to remote place(health examination)

The operation model in remote using the application was hoped for.
Therefore, a safe network design/was selected. IP-VPN was used as the main key net. Additionally, internet VPN using OpenSSH was used for the communication of a small terminal/base. Deliberate log management were done about security.

After an appropriate operation model/business flow/security management had been given, it shifted to the real operation.

We tried real operating the application and server.

The main usage is in the table.

After choosing an appropriate network security and establishing an appropriate operation model, we moved it to the real operation.

It operated in five facilities where the agreement had been obtained. About the usage/modality/period/number of the studs/number of the Images/data amount, it is the following.

Base	Usage	modarity	Period(m)
1	Dept. Radiology/Telediagnosis	CT,MR,NM	43
2	The entire hospital PACS/Telediagnosis	CT,MR,NM	31
3	Telediagnosis	CR,DR,XA,CT,MR	25
4	Diagnosis support to Remote place	CR,DR,XA,CT,MR	22
5	The entire hospital PACS/Telediagnosis	CR,CT,MR,DR, XA,US	16
	total amount		137
	average		27.4

Base	study amount	image amount	data (G)
1	51944	2003709	1022
2	22150	3322896	1864
3	1684	89666	77
4	401	31944	48
5	50867	1417371	1685
	127046	6865586	4696
	25409.2	1373117.2	939.2

It operated in five facilities.

We operated for 43 months at most and 5 terabytes data and about 6.87 million images.

Discussion

We look back on development and the real operation of this system by the viewpoint web2.0, and we considered those feasibility and possibility.

1. The Web As Platform

A series of work until selection/displaying of the image can be completed by web browser, and the system can extend by the URL space. If an appropriate network is constructed, the cooperation between another facilities is possible by web browser. In the use of the web browser main function, the link in the Internet to related information is also easy. Web browser demonstrated a high functionality as an entrance of information, and it functioned normally as a platform.

2. Harnessing Collective Intelligence and 3. Data is the Next Intel Inside

Accumulated a large amount of information was effective to a lot of cases. It was effective that the non-DICOM file was positively taken into the system.

It is thought that sharing information between another facilities is more effective. These might function cooperatively as a huge teaching file. It is thought that knowledge can be shared more efficiently if CMS such as XOOPS is used at the same time under an appropriate network.

4. End of the Software Release Cycle and 5. Lightweight Programming Models

When developing and operating it, we got the feedback from the customer. Because we selected a lightweight language, a prompt improvement was able to be done and the test version was able to be quickly offered. In the use of the test version at once by the customer, a further improvement matter arose while the matter was hot. Good feedback with the customer participation was performed.

6. Software Above the Level of a Single Device

Our system can make the equipment with the communication and the web browser function a terminal. This doesn't choose the terminal and be able to offer the possibility of service. The improvement matched to the style for which the customer hopes might raise customer satisfaction and improve their operating effectiveness.

7. Rich User Experiences

The magnification and the change of WL/WW by GUI became possible in using AJAX. The interpretation of radiogram in web browser was possible in a lot of cases according to these functions. The interpretation of radiogram of more cases can be likely to be done only by web browser in the function addition in the future. But Detailed image inspection is indispensable the interpretation of radiogram. Seamless cooperation to detailed inspection is necessary.

We developed seamless cooperation with the DICOM viewer application.

In the system, the direct DICOM interpretation united the web browser interpretation in seamlessness. As a result, the system was able to make an efficient environment.

Discussion

We considered experience from the aspect of web2.0 .

Please refer to the poster for details.

Conclusions

We thought about the system development and operation from the viewpoint of web2.0 . We interpreted the matter of web2.0, and we developed the system that reflected it .

The real operation of a long term in five facilities was experienced with the system that constructed . Operation with each facilities succeeds, and is being used by various usages now. We think that it was able to prove feasibility of the system.

We feel the possibility in effective use of web2.0 to the radiologist. We want to expand the possibility by further development and use.

Conclusions

We have develop this system from the viewpoint of Web 2.0.

The real operation of a long term in five facilities was experienced with the system that constructed .

Operation with each facilities succeeds, and is being used by various usages now.

We conclude that it was able to prove feasibility of the system.

The possibility in effective use of web2.0 to the radiologist and this system has the possibility.

We have the plan of further development for expand the possibility of Web 2.0.