# A Modeling of PACS Performance and Simulation Using Stochastic Activity Network for Optimizied Design

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*Abstract*

**To evaluate PACS performance, simulation model of PACS performance employing PetriNet was developed and the simulation was carried out. Variables used in the simulation were measured in Osaka University Hospital. We developed model for three connection types of Image Display Terminal (IDT) and servers. From results, we found that Type I is optimized design of PACS with the shortest response time among three types.**

**Key Words – PACS, Simulation, Digital Imaging**

*Introduction*

Picture Archiving and Communication System (PACS) is consisted from many components such as image modality, network, storage system and image display terminals. Since image data size is very large, response time to image request that is made on IDTs is long. PACS performance such as response time is influenced by PACS design especially connection scheme of IDTs with servers. Then, we assumed three different connection types of IDTs. To select optimized design, we developed simulation model of PACS employing stochastic activity network and carried out the simulation.

*Method*

We measured fundamental variables used in PACS performance simulation model at Osaka University Hospital. From histogram of radiologists reading intervals of medical images and consultation time at outpatient clinics, we fitted these interval times to lognormal distribution as probability distribution function. Average time of radiologist's reading time was 155sec and that of consultation in outpatient departments was 693sec. In simulation model that we developed, capabilities of network device and storage device such as hard disk drive

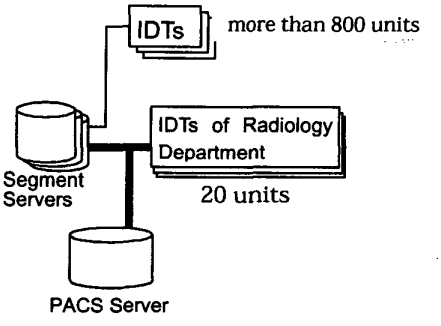


Fig.1 PACS Simulation model Type I

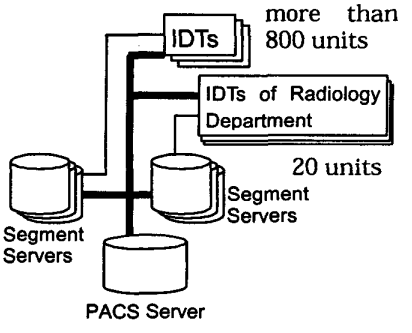


Fig.2 PACS Simulation model Type II

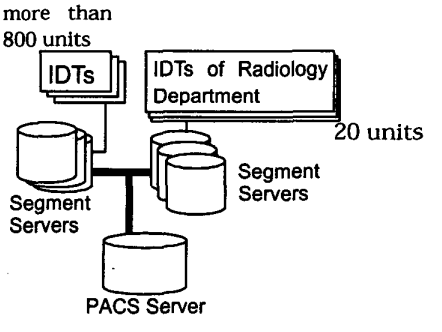


Fig.3 PACS Simulation model Type III

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Are modeled as sharing resource. To develop PACS performance model, Ultr-SAN that is discrete event simulator environment based on Stochastic PetriNet Was used in this simulation. These simulations were repeated until confidence level of each variable attained 5% of relative confidence level.

***Results and Discussion***

Simulation model Type I had highest performance among three types we assumed. In this model, IDTs except radiology department requests image via sub-network, and IDTS in radiology department requests images via main-network. As we described above, IDTs in radiology department make requests frequently and required faster response than that of other department. Because Type I satisfied these requirements, connection Type I was optimized among our selection.

In Type II mode, all IDTs are connected to both main-network and sub-network. Image request from IDTs are sent to Segment Server at first. If Segment Server does not have requested images, Segment Server sends a packet corresponding IDT to inform Segment Server does not have requested image. An IDT sends request to PACS Server successively. In this model, main-network share rate increases rapidly as increasing number of IDTs. Cost for network and for network interface of all IDTs are approximately twice to other model.

In case of Type III, all IDTs are segmented and connected to sub-network with Segment Server. IDTS in radiology department has large influences to response time of image request.

In all cases, image compression had influences to response time. However, in Type I model, the effect of image compression is lower than other model. Image compression technique can improve response time dramatically where IDT was connected to relatively lower bandwidth network.

***Conclusion***

We evaluated PACS performance using real variables and discrete event simulator based on stochastic PetriNet. From these results, we showed the influences of each connection scheme of IDTs and the influence of image compression technique to response time quantitatively. Type I connection scheme has highest performance and it was implemented to Osaka University Hospital. Image compression technique improves response time. However, in case of Type I connection, it had only slight influences to response time because of wide bandwidth of the connected networks. To improve PACS performance using image compression scheme, we found compression ratio should be selected according to connection type of IDTs.