

Reassignment of network addresses at SPring-8 control system

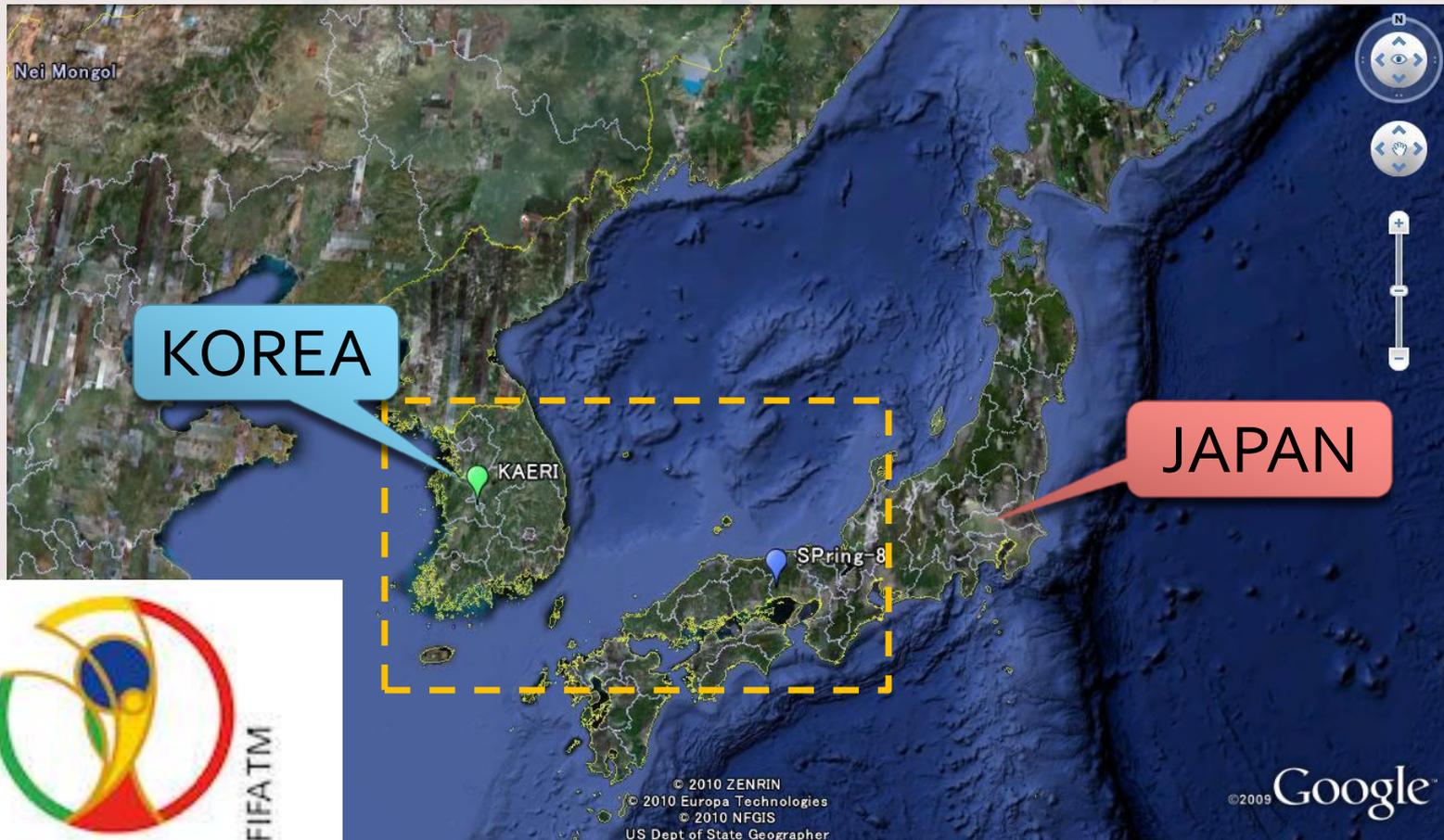
T. Sugimoto, M. Ishii, T. Ohata, T. Sakamoto, and R. Tanaka
Japan Synchrotron Radiation Research Institute / SPring-8

Outline

- Introduction
- Motivation
- Procedure
- Results and Summary

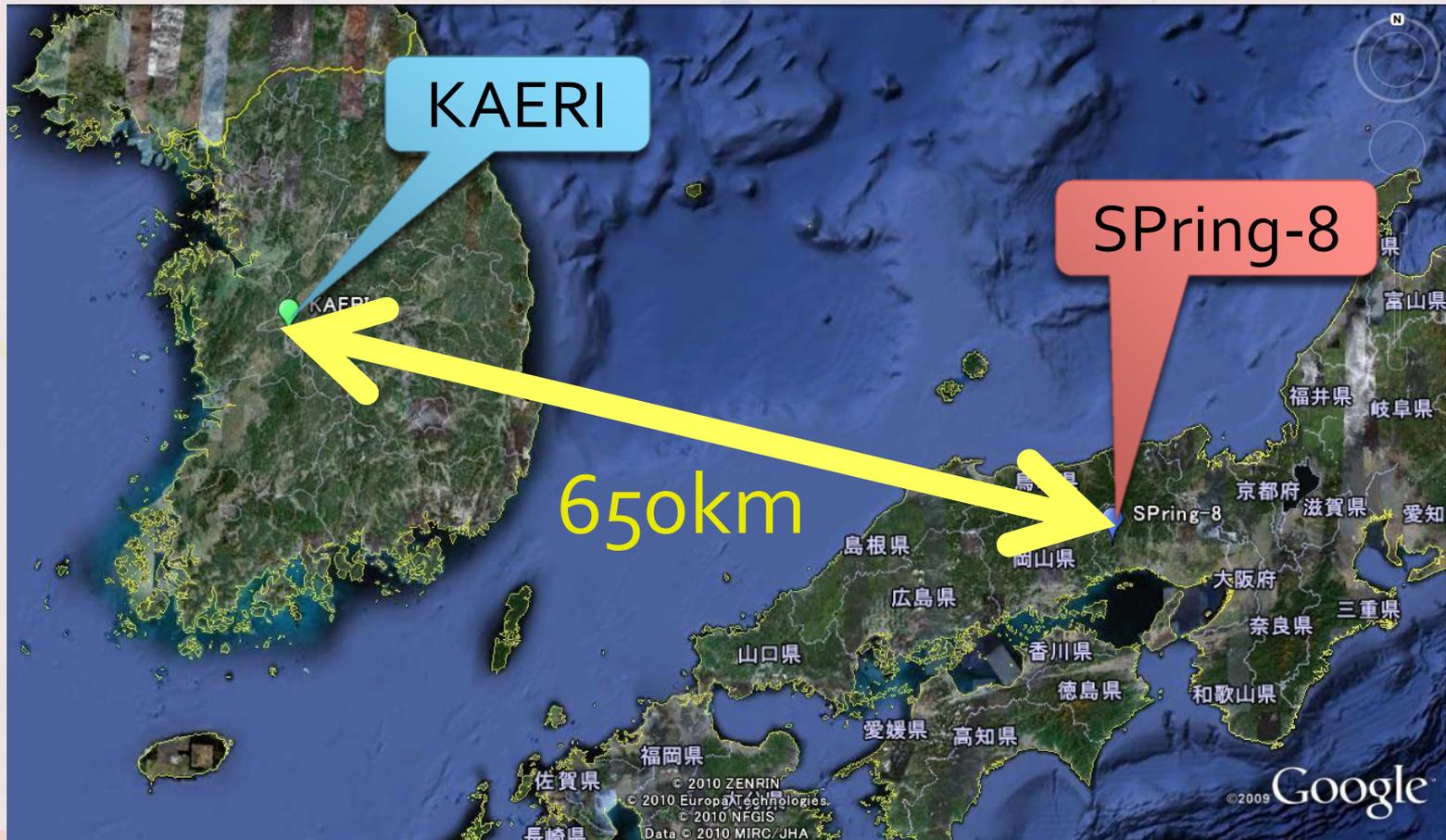
INTRODUCTION

Location: Korea and Japan



We jointly hosted FIFA World Cup 2002.

650km far from the KAERI



Bird's-eye view of the SPring-8 site

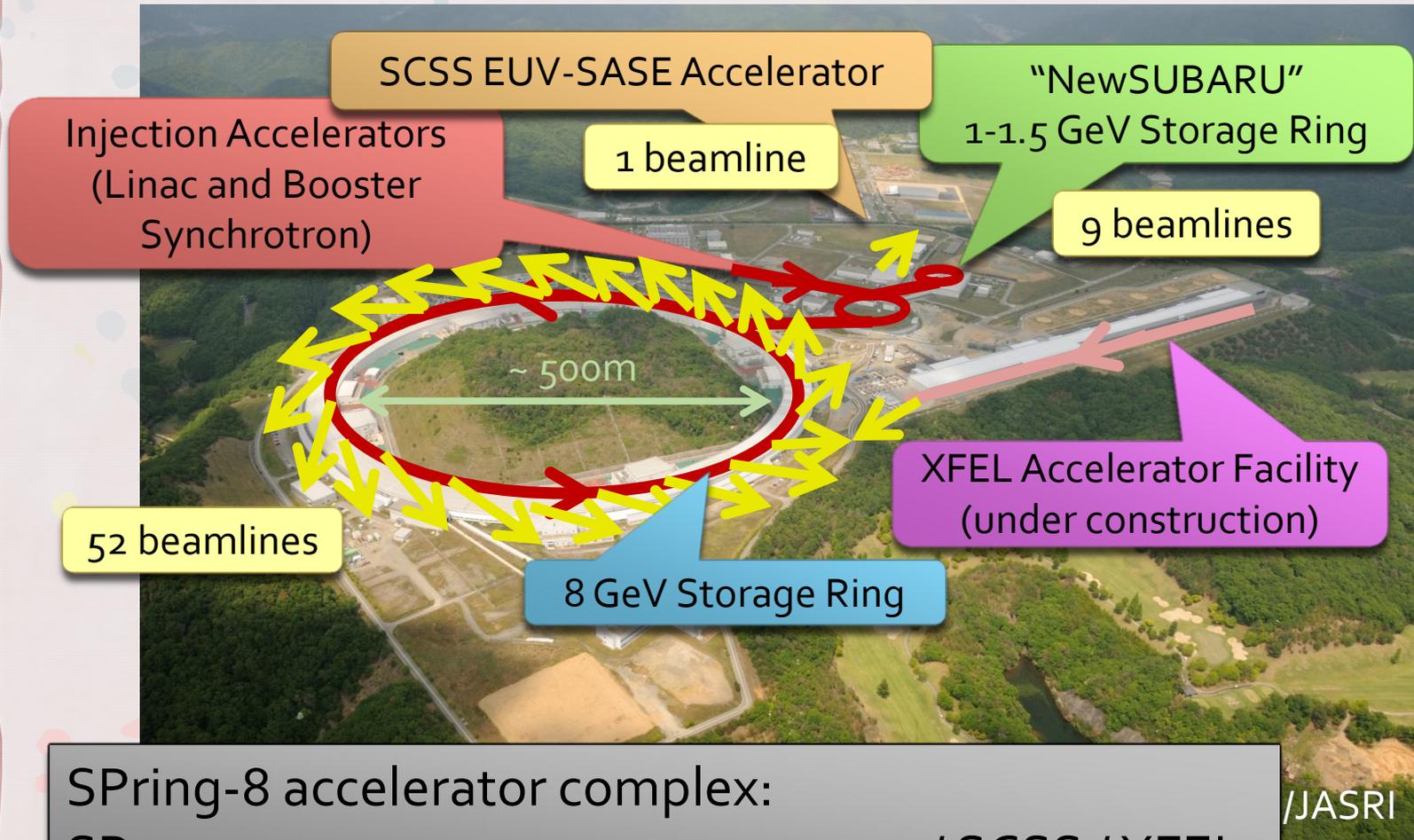


SPring-8 is the largest synchrotron radiation facility in the world.

Total site area is about $1.4 \times 10^6 \text{ m}^2$

(c) RIKEN/JASRI

Bird's-eye view of the SPring-8 site



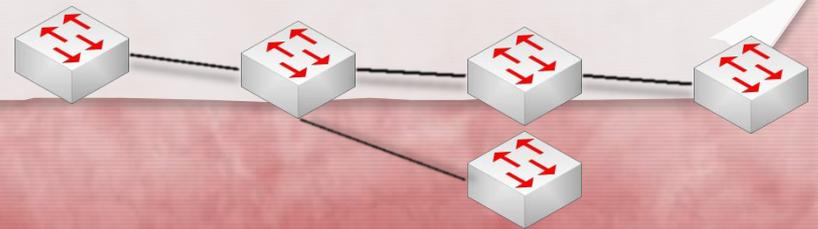
Why we need to reassgin network addresses

MOTIVATION

First days of SPring-8 control system

Original design of the network architecture based on ,

- TCP/IP technology established as standard protocol/architecture.
- Layer 2 topology without any router
 - Throughput and availability of routers were low at that time.
 - Only 350 network devices were installed, then L2 was very simple and easy to use.
- We took advantage of Ethernet as a distributed control field bus.
 - Fast packet forwarding with Ethernet switches
 - Scalability using cascaded connection



SPring-8 control system, 10 years later (~2008)

- Control system became complicated.
 - The number of network devices increased.
 - **More than 1200 devices** were connected in **single broadcast domain.** (network segment)

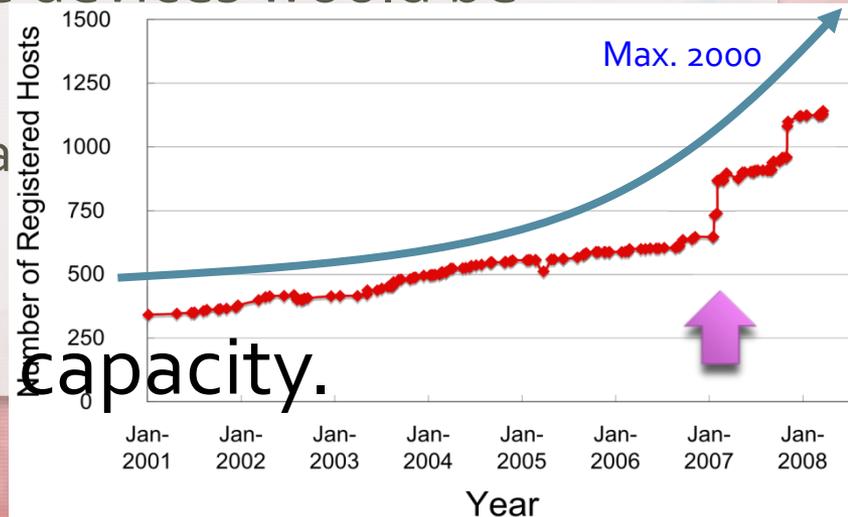
A lot of problems arose due to the network architecture.

Two examples are shown in next slides:

Problems on SPring-8 control system (1)

- IP address exhaustion
 - We used the subnet mask of 21 bit.
 - Address capacity is 2000.
 - ~100 devices were newly installed every year:
 - Virtuallization (Virtual machines)
 - Increase of network-connected devices
 - After few years, no more devices would be installed.
 - It is difficult to integrate a control system.

→ We must expand address capacity.



Problems on SPring-8 control system (2)

- Broadcast domain was too large.
 - Broadcast traffic was typ. 30 packet/sec.
 - In the burst case, broadcast traffic was raised to > 100 packet/sec.
- Broadcast packets are found to be harmful for certain network-connected embedded devices.
 - less processing capability, buffer overflow
 - Motor control unit[1]
 - Digital multimeter

→ We must shrink broadcast domain.



1. We must expand address capacity.

Most simple solution which keeps L2 topology is enlargement of broadcast domain, but ...

2. We must shrink broadcast domain.

→ Two requirements are conflicted.



Problems are caused by L2 topology!



Make a plan to change the network architecture of SPring-8 control system.

Plan to change architecture

	Previous Architecture	New Architecture
Logical Topology	Layer 2 (No router)	Layer 3 (Using L3 switch)
Address Capacity	~2000	~65000 (for each accelerator complex)
Broadcast domain (Subnet mask)	~ 2000. (21 bit mask)	~ 500 (23 bit mask)
IP Address (Class-B private)	172.24.8-15.Z	172.X.Y.Z x=20 for SP8 x=16 for XFEL, and so on.
VLAN ID	1	100X + Y
Name Resolution	NIS	DNS
Domain	(none)	4 (sp8.cntl.local, xfel.cntl.local, etc.)

Details: T. Sugimoto et. al: Proceedings of ICALEPCS2009, WED006 (2009)

Network segment: Router v.s. L3 switch

Segmented network needs IP forwarding (L3) network instruments.

Router

- Historically used
- Low throughput
 - Software based
- Multifunction

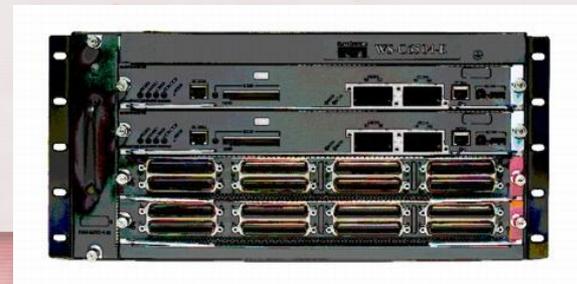
We don't need most part of functions!

- High reliability
- Availavility: intermediate
 - 10 sec failover by VRRP



L3 Switch

- Available in end of 1990s
 - High throughput
 - Hardware based
 - Limited function
- We don't need most part of functions!
- High reliability
 - High availavility
 - < 1 sec failover by stacking

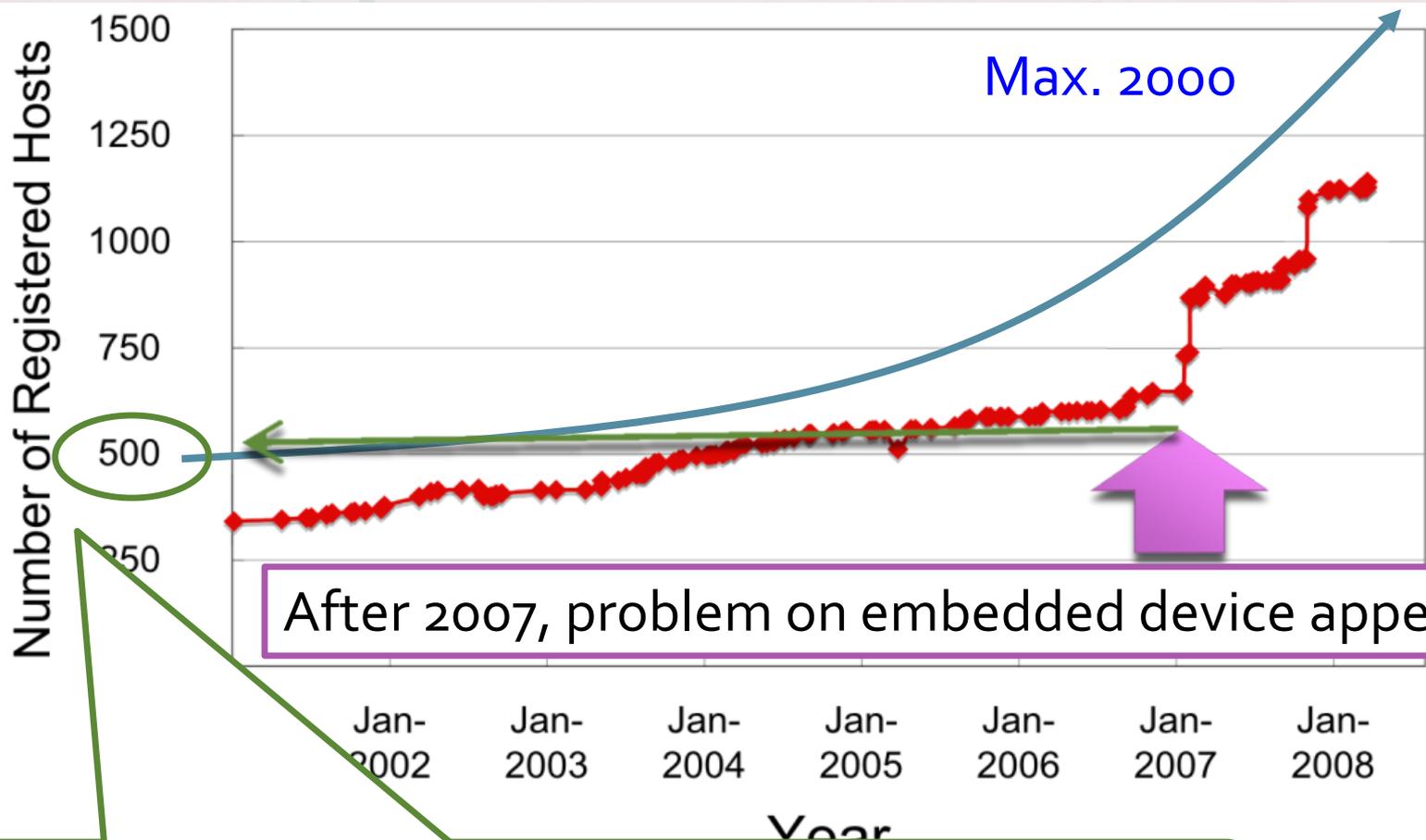


Cisco Catalyst 6504E VSS: to be installed in 2010

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Why we choose 23 bit mask.



We allocate "~500" (/23) IP address space to single broadcast domain.

Plan to change architecture

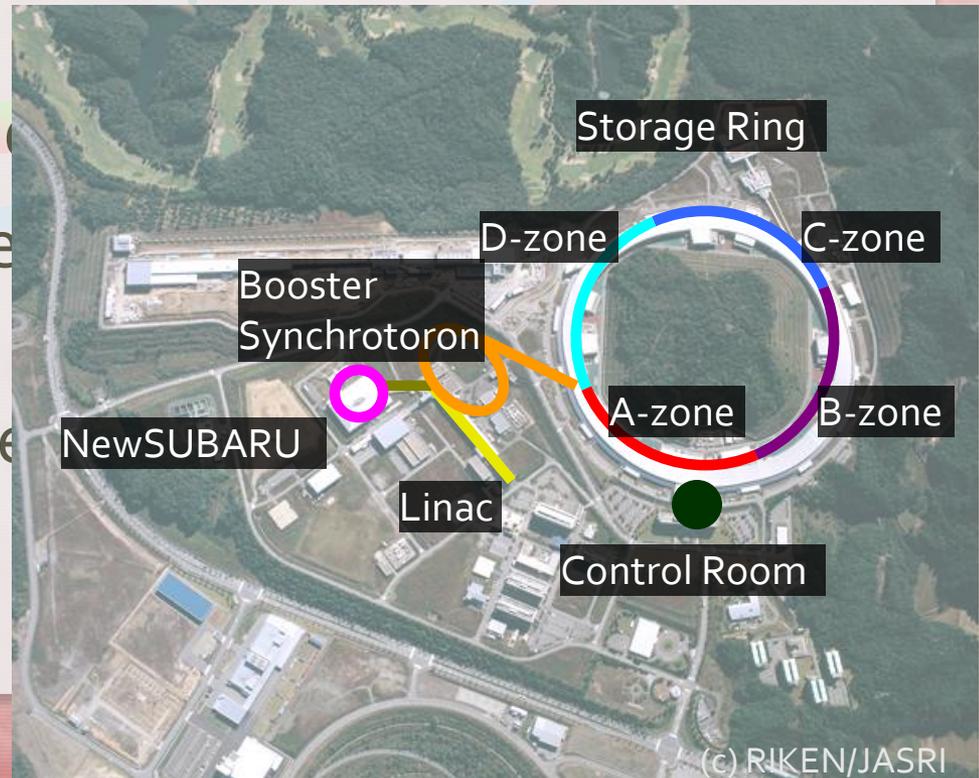
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To accomplish changing architecture,
it is necessary to reassign IP addresses.

Details: T. Sugimoto et. al: Proceedings of ICALEPCS2009, WED006 (2009)

New Network Architecture

- Archive stable network operation
 - Reduce broadcast domain, because we must guard devices, which are vulnerable to heavy traffic.
- We changed single network architecture
 - Network is segmented into zones of devices.
 - We can append new devices to the network.



How to change network architecture

PROCEDURE

Procedure

- Boundary condition
 - Address reassignment must be finished by the end of summer shutdown period (~ 1 month).
 - New network configuration must work no later than 2 days after the end of the scheduled period.
- Estimated project period
 - Test and exercise: 1 month
 - Setup and reconfiguration: 4 days
 - Validation: 1 month

Should be done by control division staff .

- We cooperated with > 10 persons.

Test and exercise (July, 2009)

- Test first, and exercise address reassignment procedure.
 - We built a test bench simulating the actual control system.
 - We held rehearsal 4 times:
 - Examine shell scripts, which change IP addresses of > 100 devices at a time.
 - Find out and fix problems.
 - Estimate required time.

Feedback from exercise

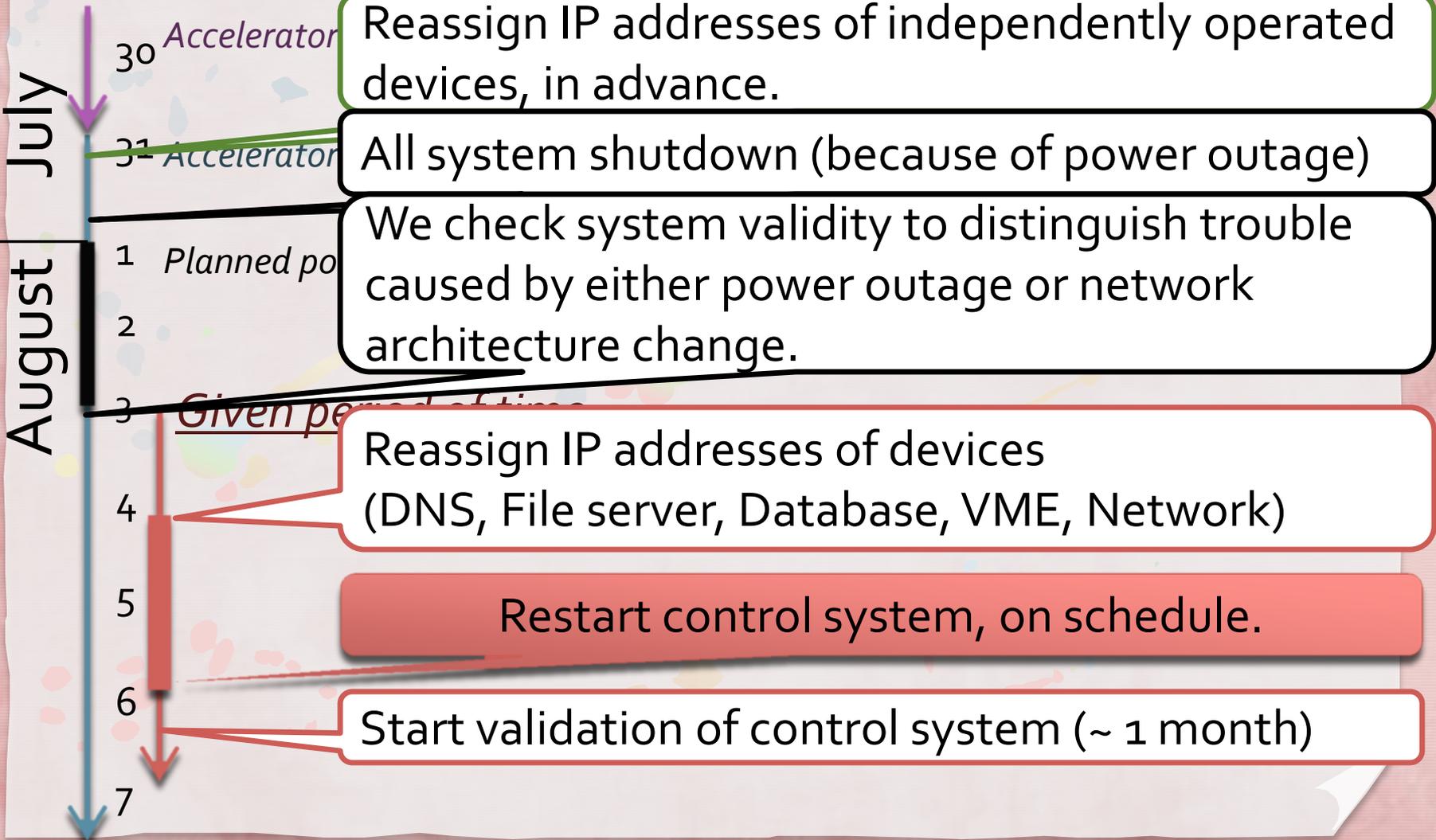
- From the exercise experience, we refined work procedure as follows:

1. Name resolution
2. File server
3. Database
4. VMEs
5. Network
6. Other instruments

Estimated required time was 2 days.

Confirmation and confidence to achieve successful reassignment – then do it.

Execution (August 3—6, 2009)



Validation (August 7 – 31, 2009)

- Almost all control devices were OK.
 - A few problems remain
 - We could not configure default gateway of VERY OLD devices.
 - Multi-channel analyzer purchased in 1990s
 - L2-based maintenance terminal did not work.
- To resolve such problems, we configure port-based VLANs for these devices.

Spring-8 control system was ready to run
at the end of August.

RESULTS AND SUMMARY

Results

- Network architecture of SPring-8 control system is completely changed from L2 to L3 topology.
- We measure address exhaustion.
 - IP address capacity is upgraded from 2,000 to 65,000.
- We also resolve broadcast domain problem.
 - Broadcast traffic is reduced from 30 pps to < 1 pps, and no burst has been observed.
 - Now, motor control unit is operated with no trouble.

Summary

- Network architecture of SPring-8 is changed to L3.
 - Motivation: resolve problems caused by L2 topology
 - IP address exhaustion
 - Too large broadcast domain
- Man power
 - It took < 4 days with > 10 persons. (~ 50 man-days)
 - We changed > 1000 devices distributed in large SPring-8 site.
 - Shell scripts are useful to change many devices at a time.
- Other benefit
 - Asset management
 - We assigned responsible person to each device, which was not assigned to.
 - We removed ~ 200 devices, which were not used any longer.
- And now, SPring-8 is in operation very stable.

Thank you for your attention!



さくら – Cherry blossoms near the SPring-8, April 2010