



Management of the Motion Control in Large-Scale System

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on behalf of the undulator control systems group

The European X-Ray Free Electron Laser



- European XFEL facility overview
- Undulator Systems
- Objectives
- Image Distribution Automation
 - Operation Principals
 - Components
 - Image and Parameters Update
 - Creating a Master Image
 - Additional functionalities
- Conclusions



The **European XFEL (X-Ray Free-Electron Laser)** is a research facility under construction which will use high intensity X-ray light to help scientists better understand the nature of matter.



- Location:
Schenefeld and
Hamburg, Germany
- User facility with
260 staff (+ 230
from DESY)
- 2017 start of user
operation

Facility overview



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Schenefeld



- Experiment hall
- Laboratories
- Offices

Osdorfer Born

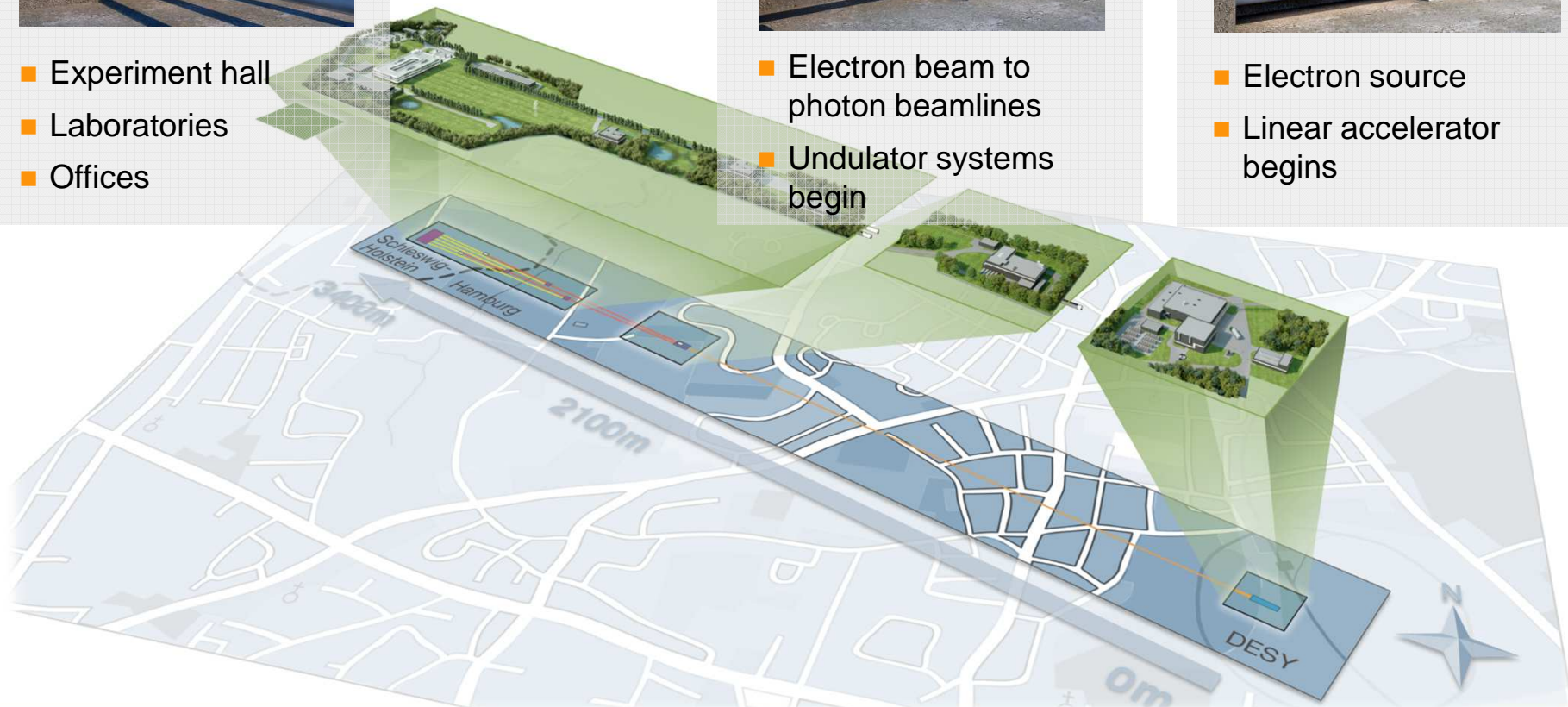


- Electron beam to photon beamlines
- Undulator systems begin

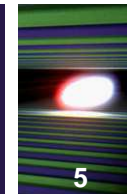
DESY-



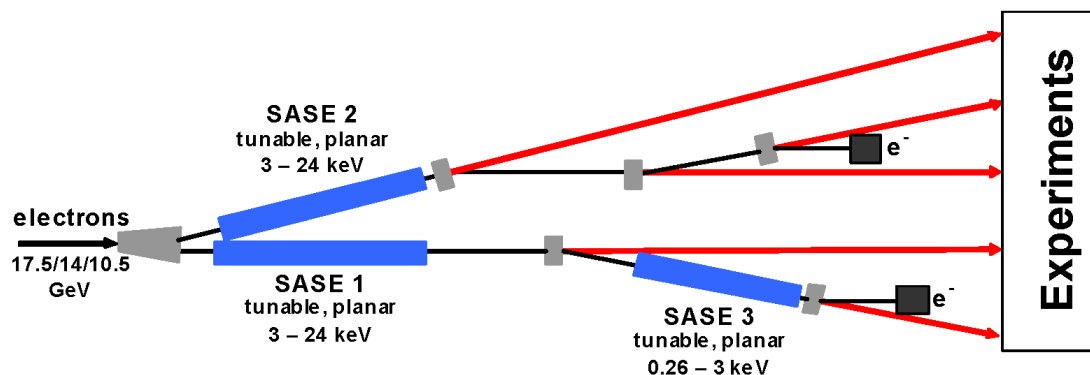
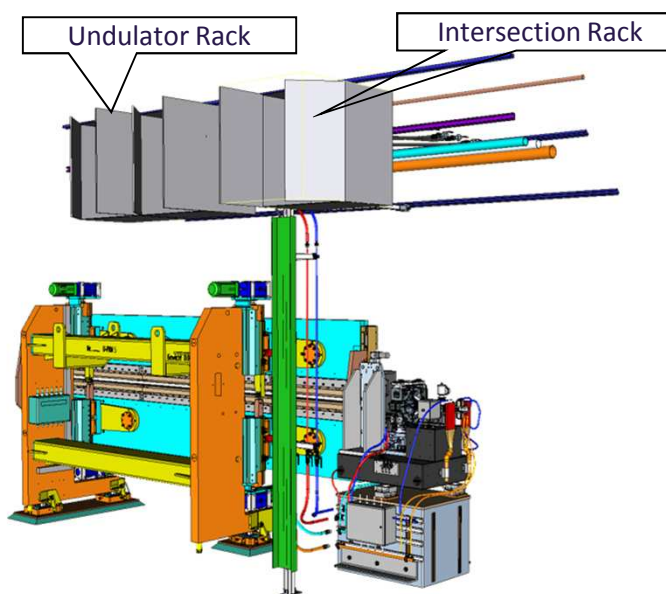
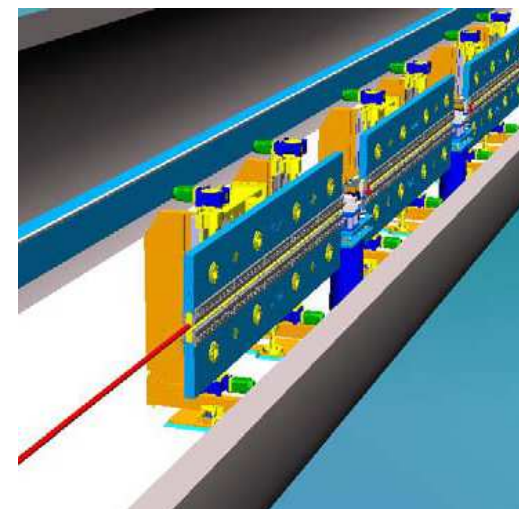
- Electron source
- Linear accelerator begins



Undulator Systems

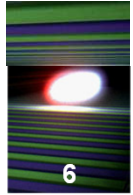


Beamline	Electron energy GeV	Photon energy keV	Wavelength Å	Gap mm	λ_U mm	Quantity of Undulators
SASE1	10.5	2.3 – 14.9	5.4 – 0.83	10 - 24		
&	14	4.1 – 18.7	3.0 – 0.66	10 - 20	40	35
SASE 2	17.5	6.4 – 29.2	1.9 – 0.43	10 - 20		
SASE 3	10.5	0.26 - 2.2	47.7 – 5.6	10 - 28		
	14	0.47 - 2.6	26.6 – 4.8	10 - 24	68	21
	17.5	0.73 - 4.1	16.9 – 3.0	10 - 24		
						Total: 91



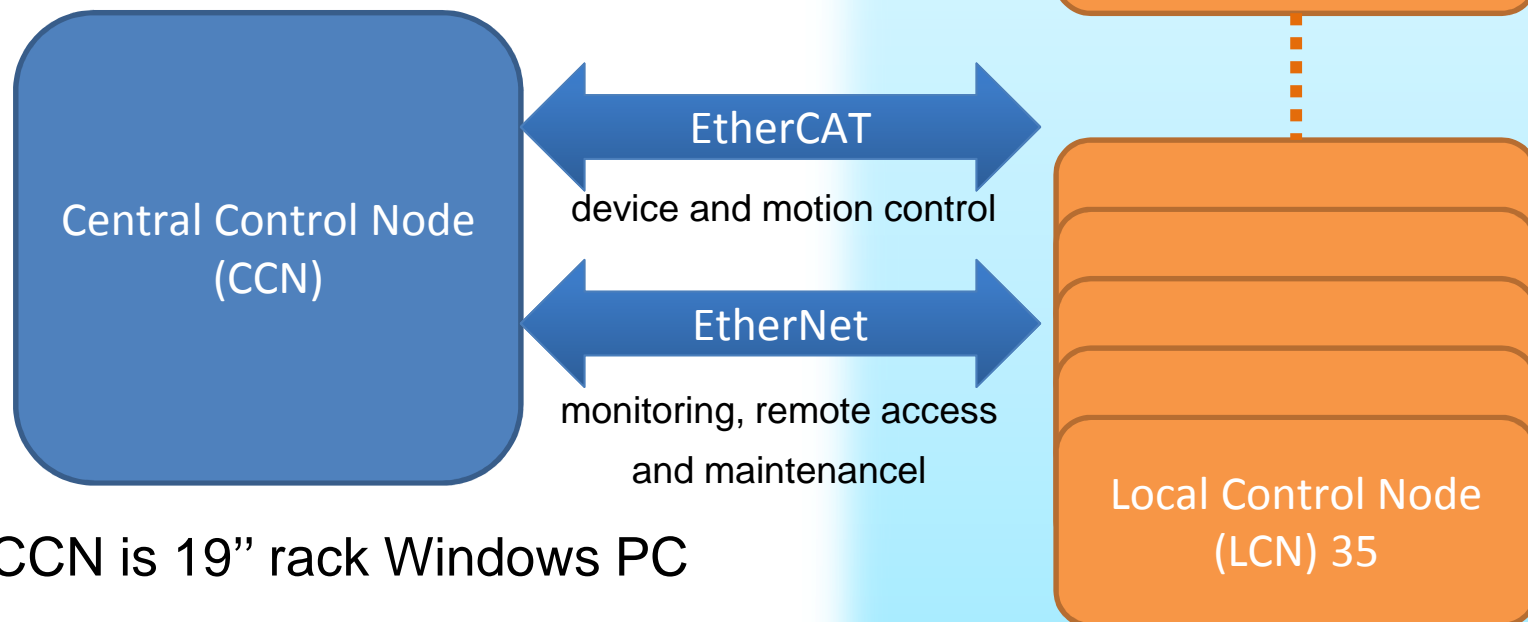
■ Undulator cell

Undulator Control System



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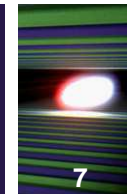
- The undulator control system is based on industrial components produced by Beckhoff company and a PLC implemented in the TwinCAT system.



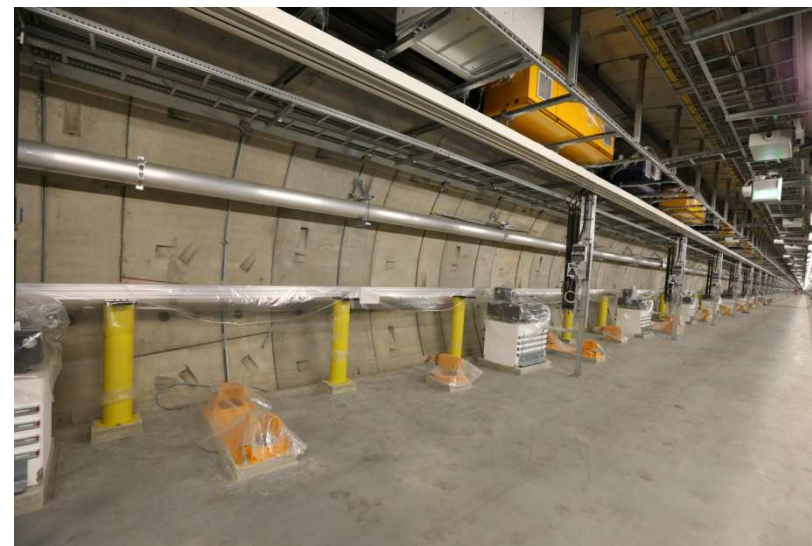
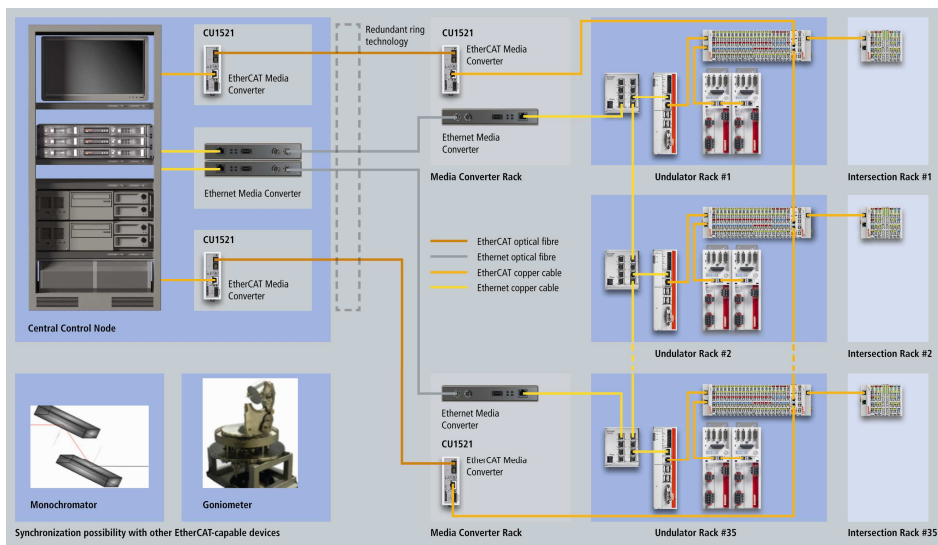
- CCN is 19" rack Windows PC

- LCN is Beckhoff industrial Windows PC

Network Topology of an Undulator System



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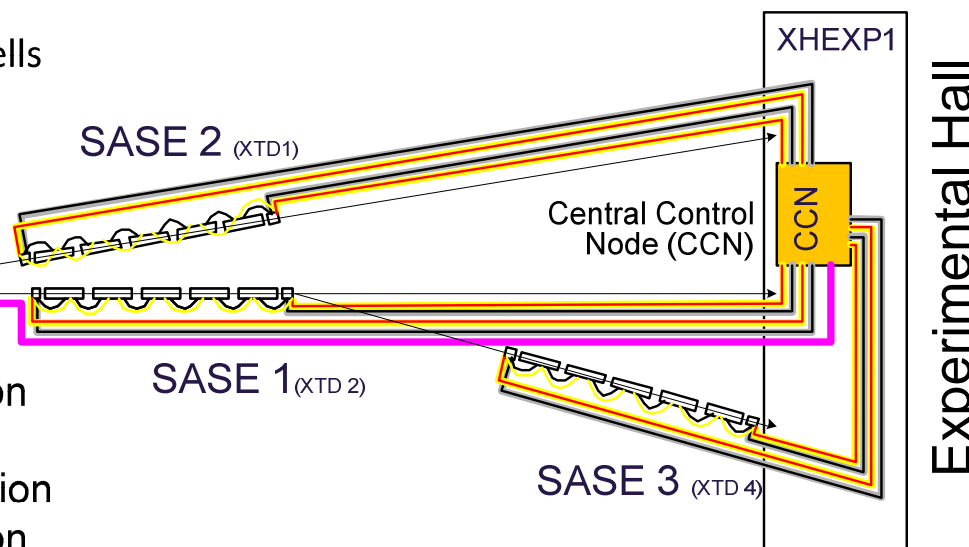
Daisy-chained racks of undulator cells

Optical fiber connection to the accelerator control network

XXSIN / XTIN / XSE



- EtherCAT optical fiber connection
- Ethernet optical fiber connection
- EtherCAT copper cable connection
- Ethernet copper cable connection

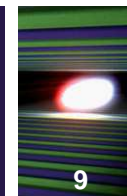




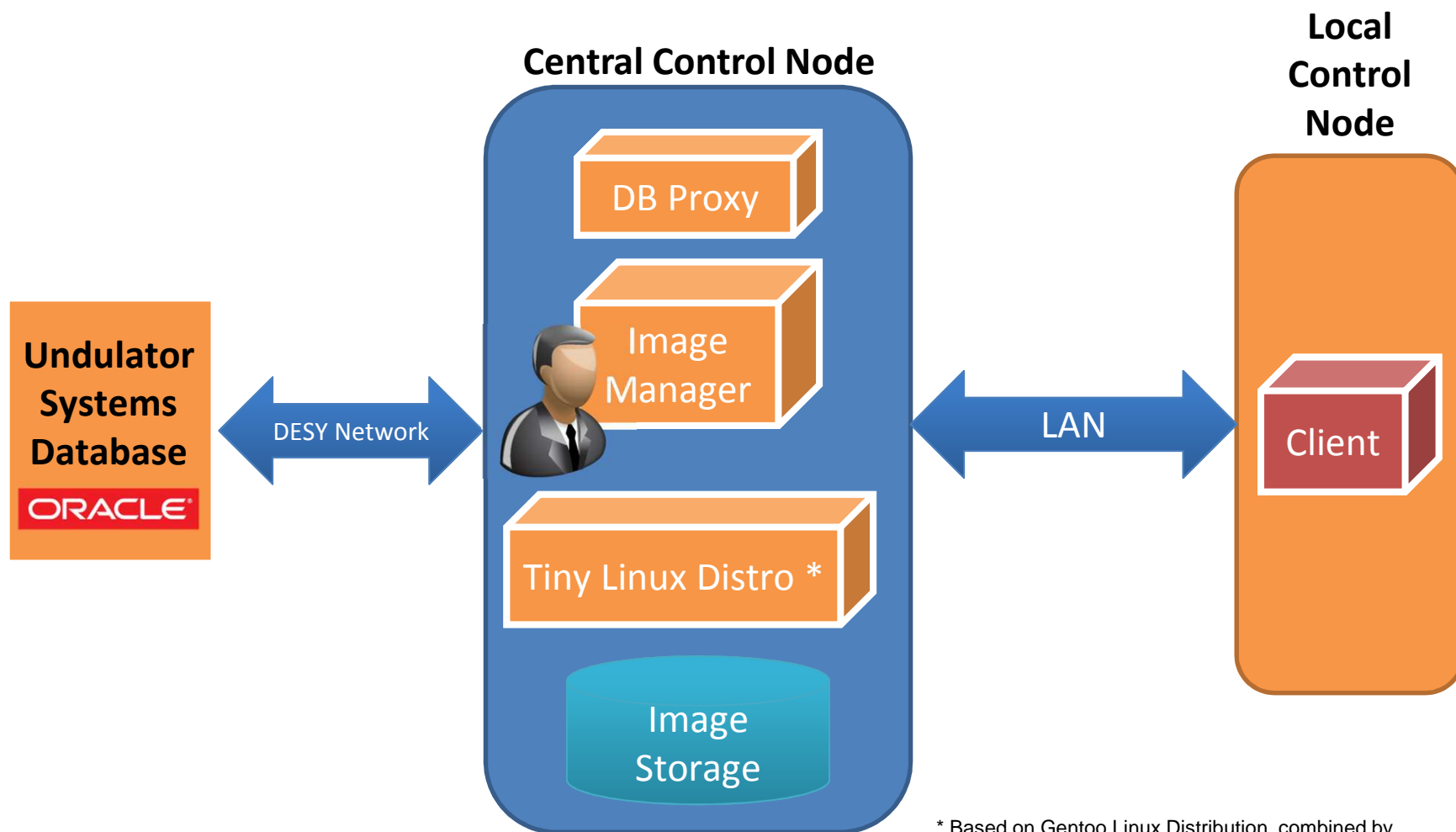
Problems by Setting up a Local Control Node (LCN)

- To change any parameter in LCN, it was necessary to go to tunnel or use Remote Desktop
- To clone image, it was necessary to use card reader
- No way to obtain data from Database
- Manually changing each individual parameter (Position bias, Motor torque value, Coefficient files, Tables ...) on each Undulator
- Manual startup configuration after cloning (IP addresses, AMS Net ID, EtherCAT device ID ...)
- Time consuming, error prone
- The commissioning and maintenance of such a large-scale distributed system were necessary to automate

Image Distribution Automation (IDA) Operation Principals

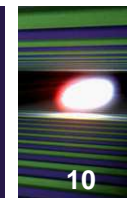


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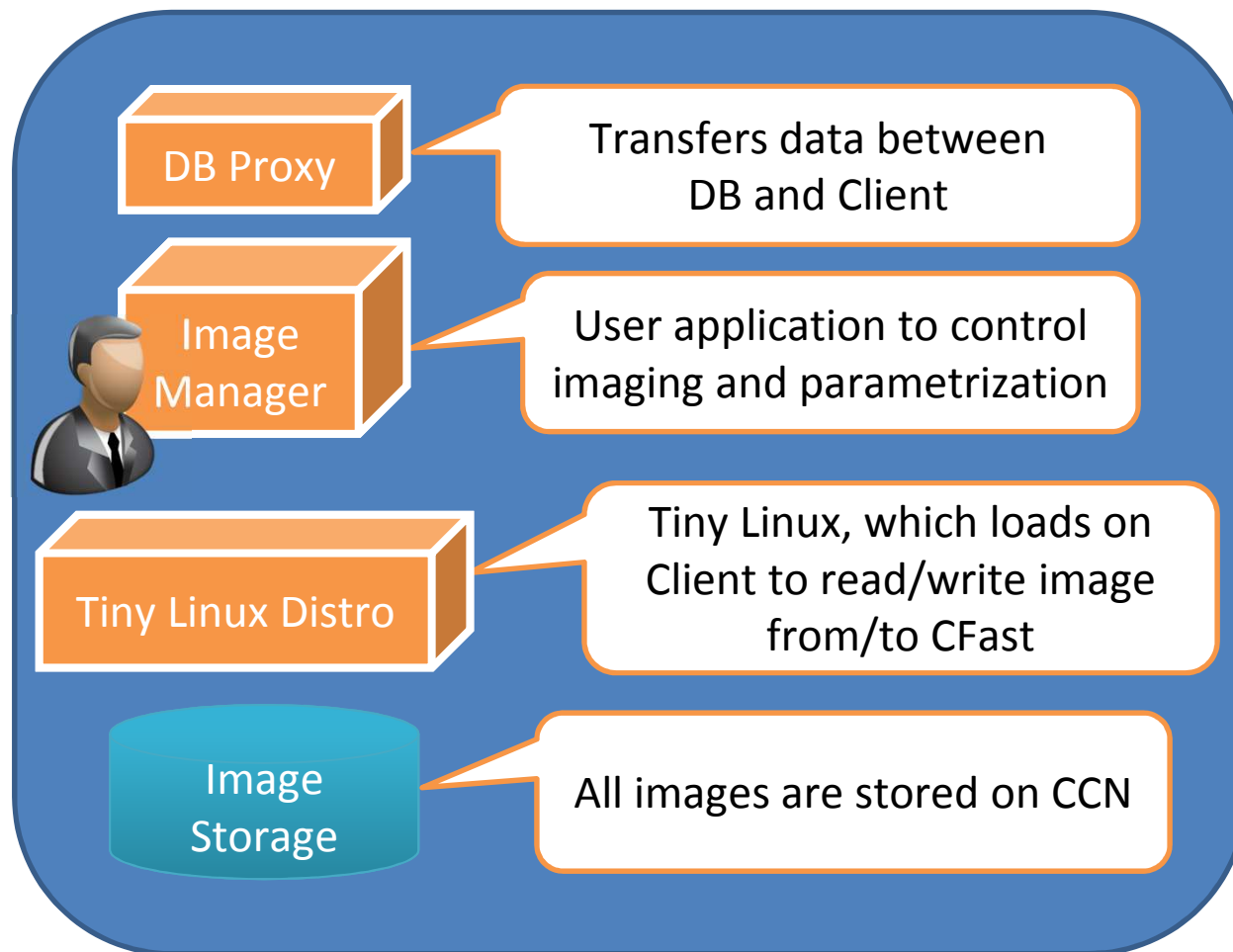


* Based on Gentoo Linux Distribution, combined by
Martin L. Purschke, Brookhaven National Laboratory

Image Distribution Automation Components



Central Control Node



Local Control Node

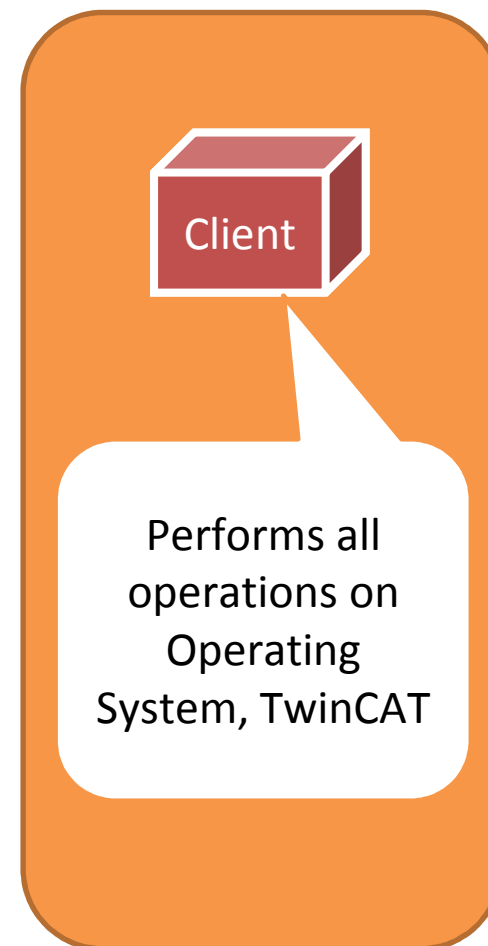


Image Distribution Automation

Update Image

Image Manager --- version: 2.0.2.175

Cells Settings

<input type="checkbox"/>	Cell	IP Address	MAC Address	Version	Status	Ping	Operation	Last Status
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<input type="checkbox"/>	2	10.10.1.2	N/A			✗		No Action
<input type="checkbox"/>	3	10.10.1.3	000105128202		✓	✓	Done, rebooting...	29-Sep-15 3:13:33 PM
<input type="checkbox"/>	4	10.10.1.4	0001050FE396		✓	✗		07-Oct-15 11:18:32 AM
<input type="checkbox"/>	5	10.10.1.5	000105116466		✓	✗		07-Oct-15 10:25:30 AM
<input checked="" type="checkbox"/>	6	10.10.1.6	0001050DEC44		✓	✗		07-Oct-15 10:27:16 AM
<input type="checkbox"/>	7	10.10.1.7	N/A		✓	✗		23-Sep-15 5:09:26 PM
<input type="checkbox"/>	8	10.10.1.8	N/A			✗		No Action
<input type="checkbox"/>	9	10.10.1.9	N/A			✗		No Action
<input type="checkbox"/>	10	10.10.1.10	N/A			✗		No Action
<input type="checkbox"/>	11	10.10.1.11	N/A			✗		No Action
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<input type="checkbox"/>	19	10.10.1.19	N/A			✗		No Action
<input type="checkbox"/>	20	10.10.1.20	0001050DEC54		✓	✗		06-Oct-15 9:31:49 PM
<input type="checkbox"/>	21	10.10.1.21	N/A			✗		No Action
<input type="checkbox"/>	22	10.10.1.22	N/A			✗		No Action
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<input type="checkbox"/>	27	10.10.1.27	N/A			✗		No Action
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<input type="checkbox"/>	31	10.10.1.31	N/A			✗		No Action
<input type="checkbox"/>	32	10.10.1.32	N/A			✗		No Action

Operations

Update Params Update Image Refresh Versions Refresh Status Refresh Ping Make Master Filter

Undula
System
Databa

ORAC

Image Distribution Automation Update Parameters

Image Manager --- version: 2.0.2.175

Cells Settings

<input type="checkbox"/>	Cell	IP Address	MAC Address	Version	Status	Ping	Operation	Last Status
<input type="checkbox"/>	1	10.10.1.1	N/A			✗		No Action
<input type="checkbox"/>	2	10.10.1.2	N/A			✗		No Action
<input type="checkbox"/>	3	10.10.1.3	000105128202		✓	✓	Done, rebooting...	29-Sep-15 3:13:33 PM
<input type="checkbox"/>	4	10.10.1.4	0001050FE396		✓	✗		07-Oct-15 11:18:32 AM
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<input type="checkbox"/>	20	10.10.1.20	0001050DEC54		✓	✗		06-Oct-15 9:31:49 PM
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Operations

Update Params Update Image Refresh Versions Refresh Status Refresh Ping Make Master Filter

Image Distribution Automation (IDA)

Make Master Image

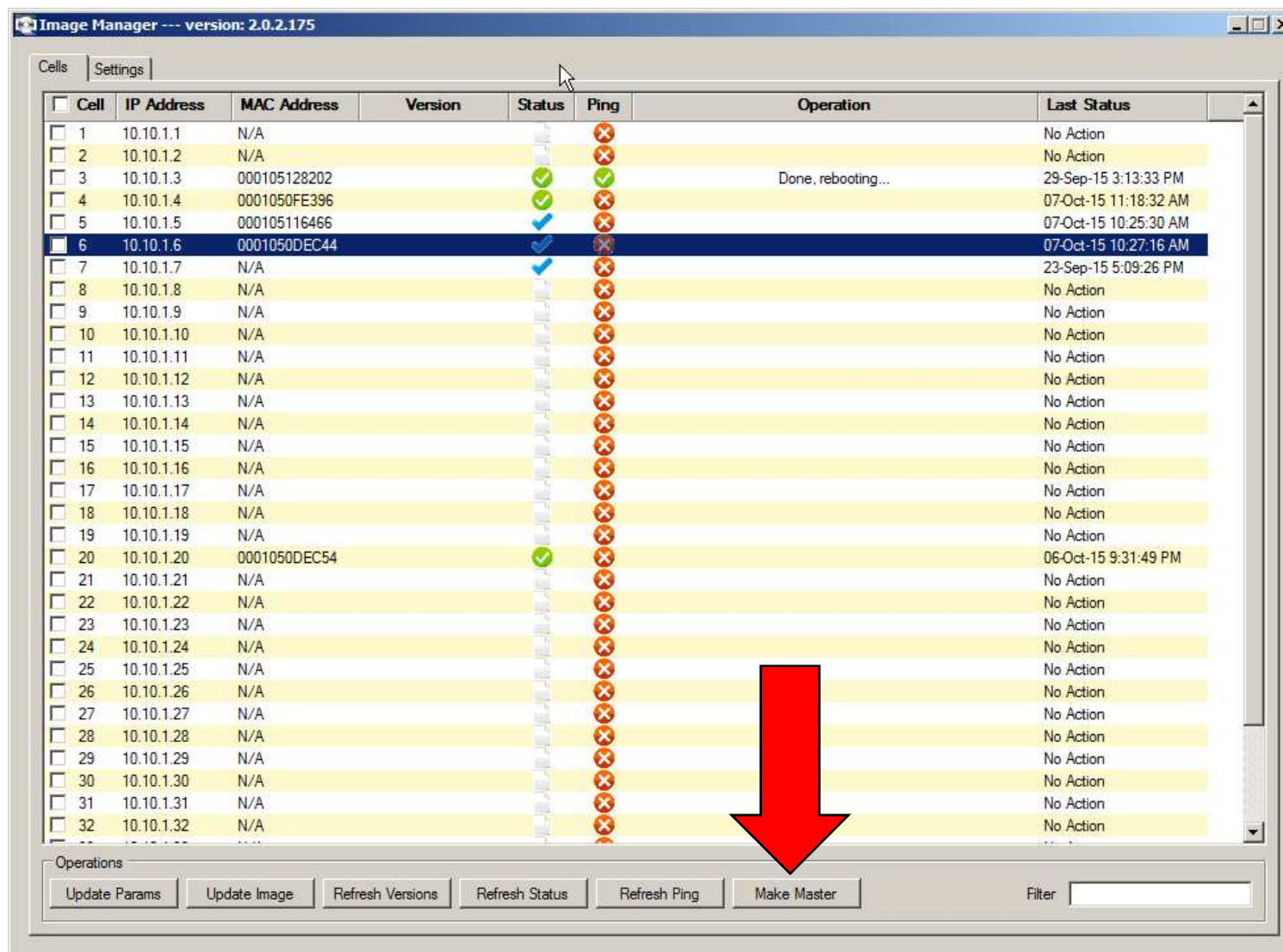
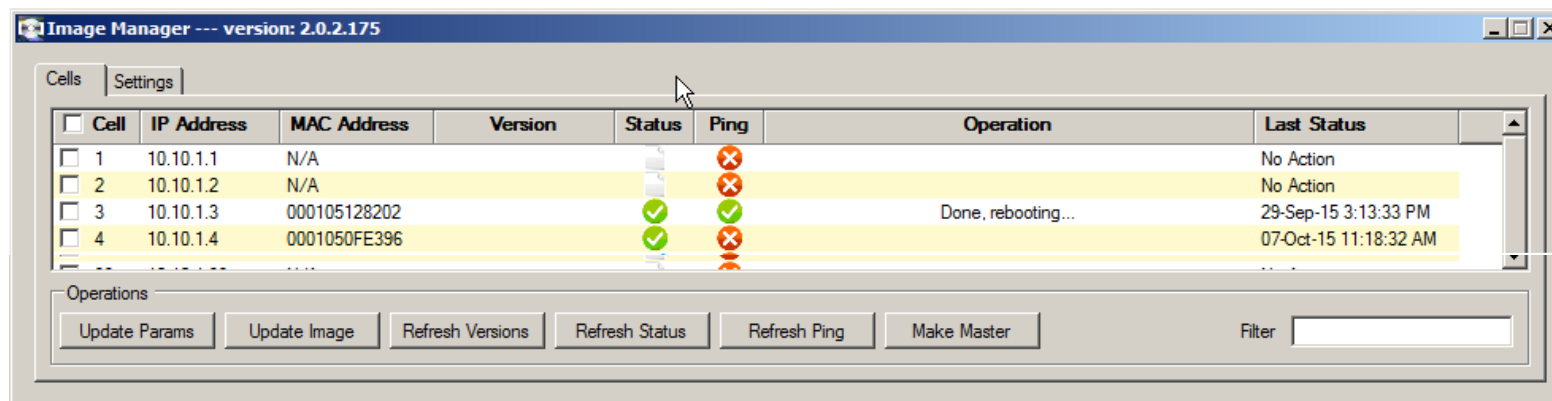


Image Distribution Automation

Additional functionalities

- Showing image versions of each undulator, showing if local control node is alive



- Showing status and date of last operation

The screenshot shows the 'Details' window, which displays a table with the following columns: AMS NetID, EtherCAT IP, X102 IP, Host Name, Position Bias, Torque, EtherCAT DID, AC Table, BS Table, CC Table, OS Rebooted?, TC Rebooted?, and Date. The table contains three rows of data:

AMS NetID	EtherCAT IP	X102 IP	Host Name	Position Bias	Torque	EtherCAT DID	AC Table	BS Table	CC Table	OS Rebooted?	TC Rebooted?	Date
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	No	Yes(OK)	07-Oct-15 10:27:16 AM
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	No	No	06-Oct-15 8:55:08 PM
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	No	No	06-Oct-15 8:50:22 PM

- Details window shows each operation and result
- It's possible to filter the list of undulators

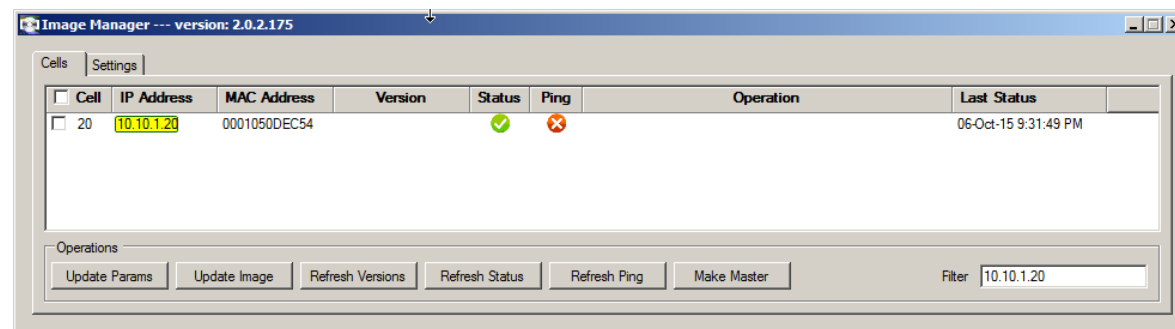


Image Distribution Automation Conclusions



- Made easy to create master image without going to tunnel or doing manual work remotely
- Made possible to have one click image deployment on all local computers
- Is extensible, so new parameters can be added very fast
- Saves time and eliminates most of errors
- Automats the commissioning and maintenance of large-scale distributed system.

Thank you for your
attention!

Undulator control system components

