Next-Generation MADOCA for The SPring-8 Control Framework

T. Matsumoto, Y. Furukawa, M. Ishii
JASRI/SPring-8

Outline

- Introduction to MADOCA
- MADOCA II Messaging
- MADOCA II Applications
- Summary

Introduction to MADOCA

- Control Framework originally developed at SPring-8, Japan
- Adopted in several facilities for various control applications
  - SPring-8, SACLA, NewSUBARU, HiSOR
  - Accelerator, beamline and experimental station controls
- Successfully utilized since 1997

*Photos courtesy of RIKEN/JASRI

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  - **M**essage **A**nd **D**atabase **O**riented **C**ontrol **A**rchitecture
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  - Examples:
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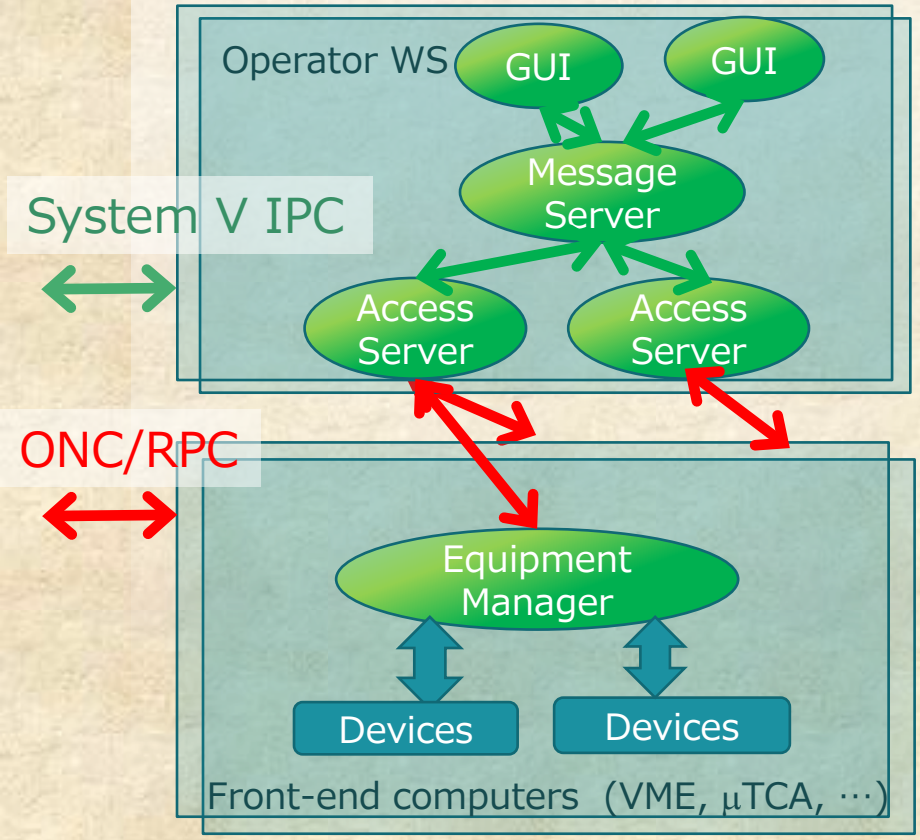
→ These features are essential in our control system

MADOCA Control Framework



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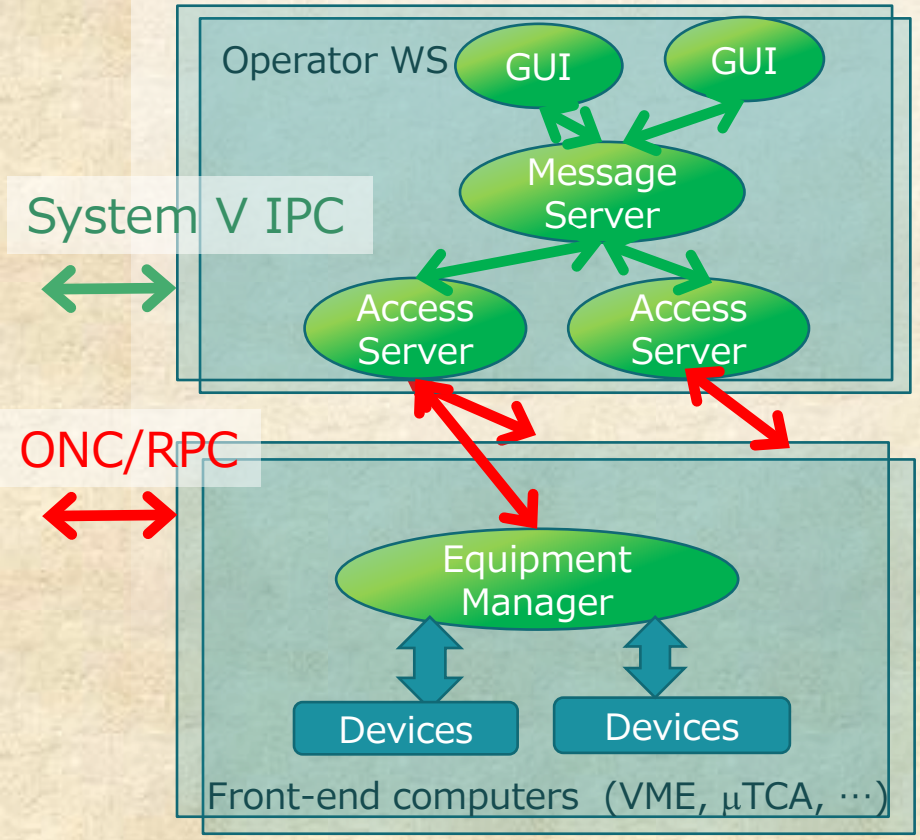
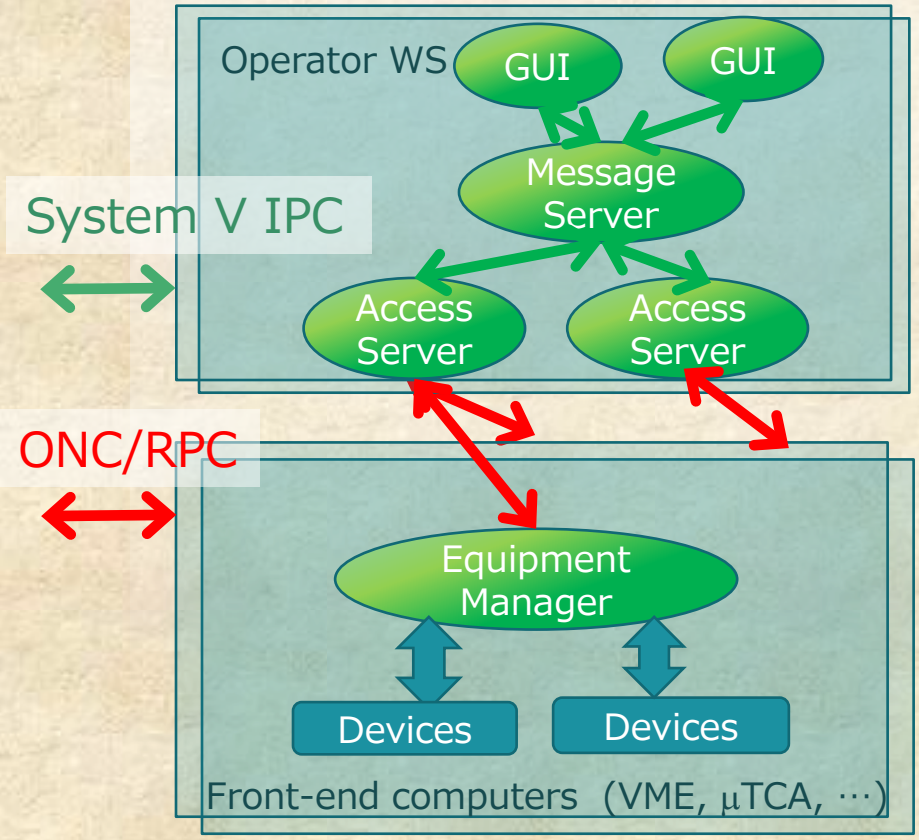


Shortcomings

MADOCA Control Framework



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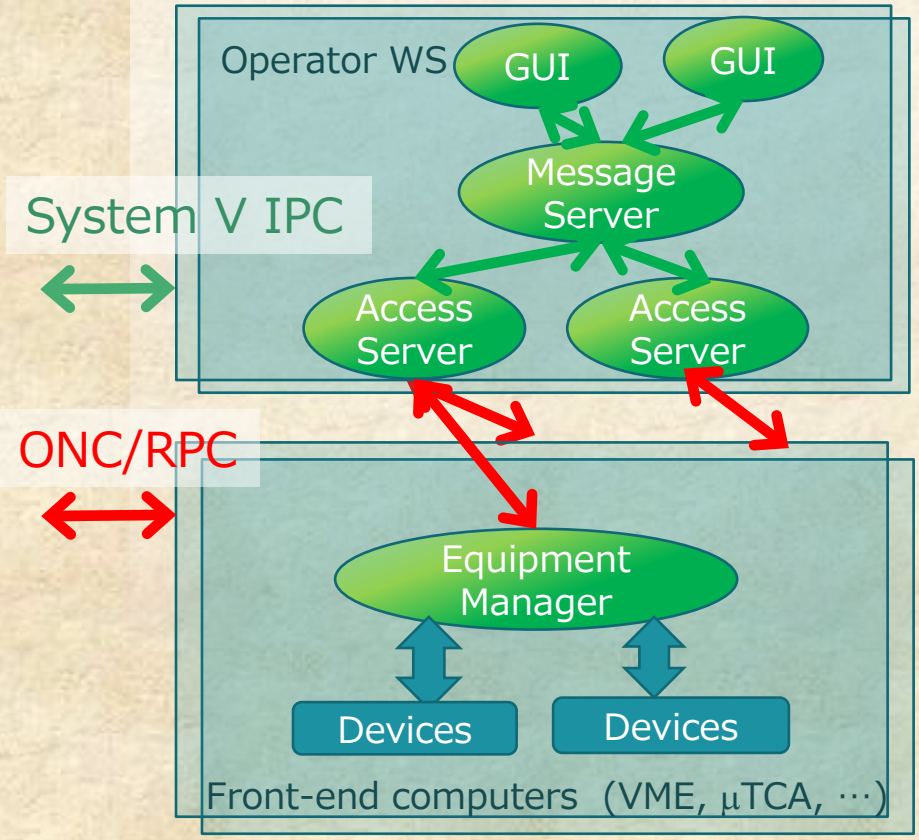

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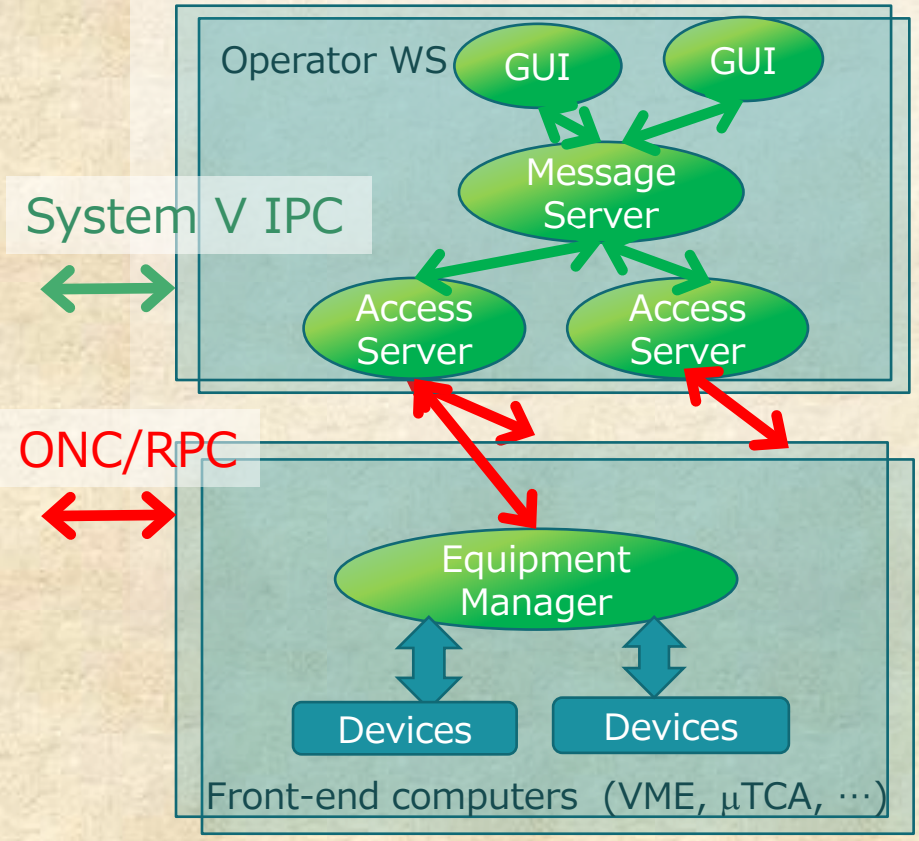

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- Synchronous communication in ONC/RPC
  - Need to wait to finish processing of each message

Next-Generation MADOCA, MADOCA II

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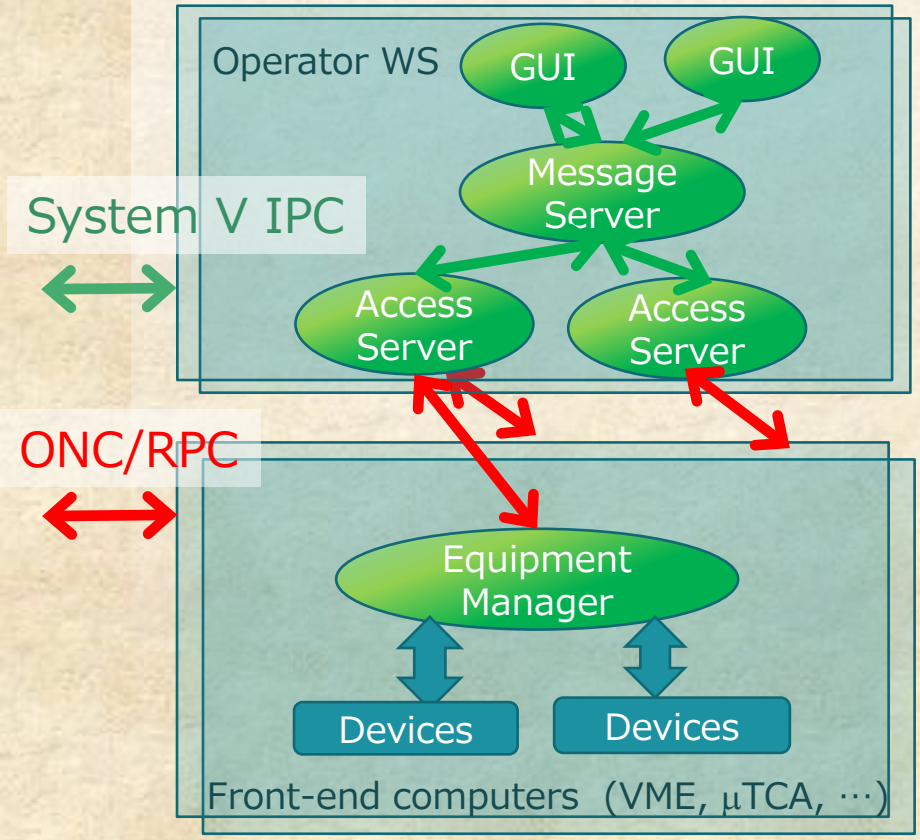
✓ Messaging with ZeroMQ/MessagePack

✓ Data logging with NoSQL (Cassandara, Redis)

→ Refer M.Kago et al. on TUPPC08

– "Development of a Scalable and Flexible Data Logging System Using NoSQL Databases"

MADOCA


Operator WS
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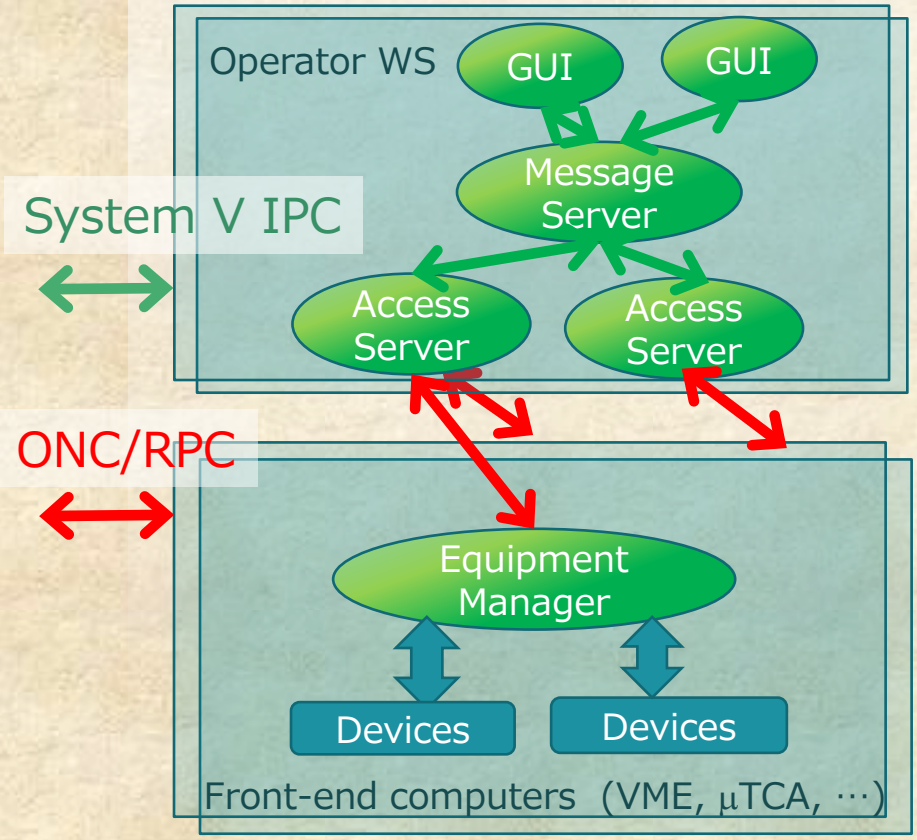

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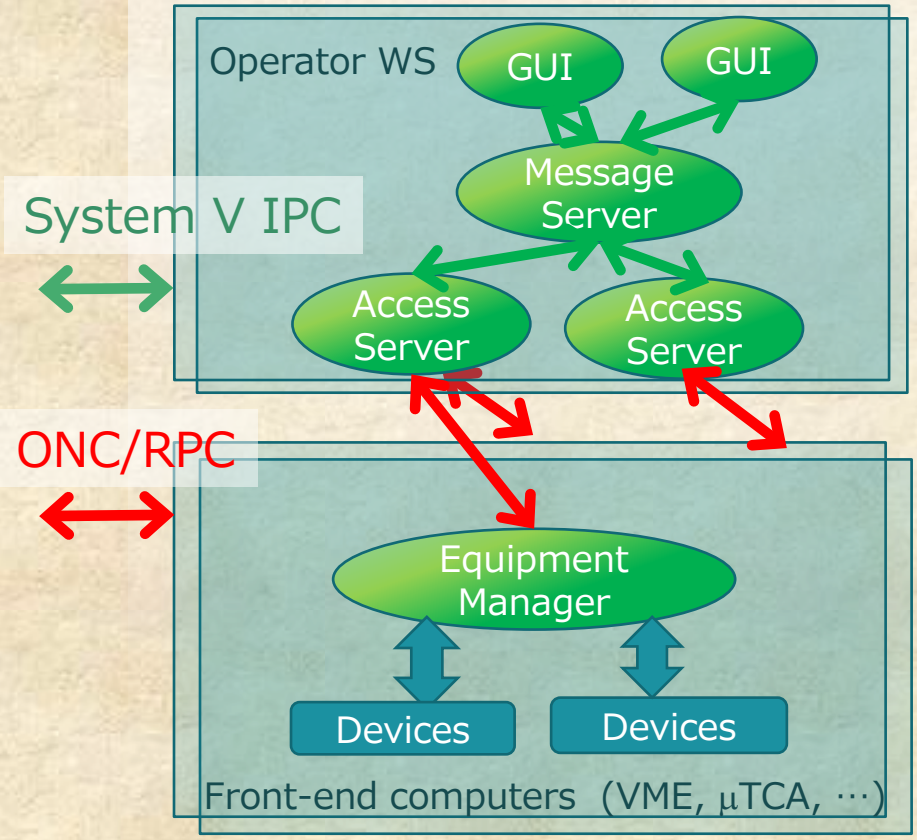

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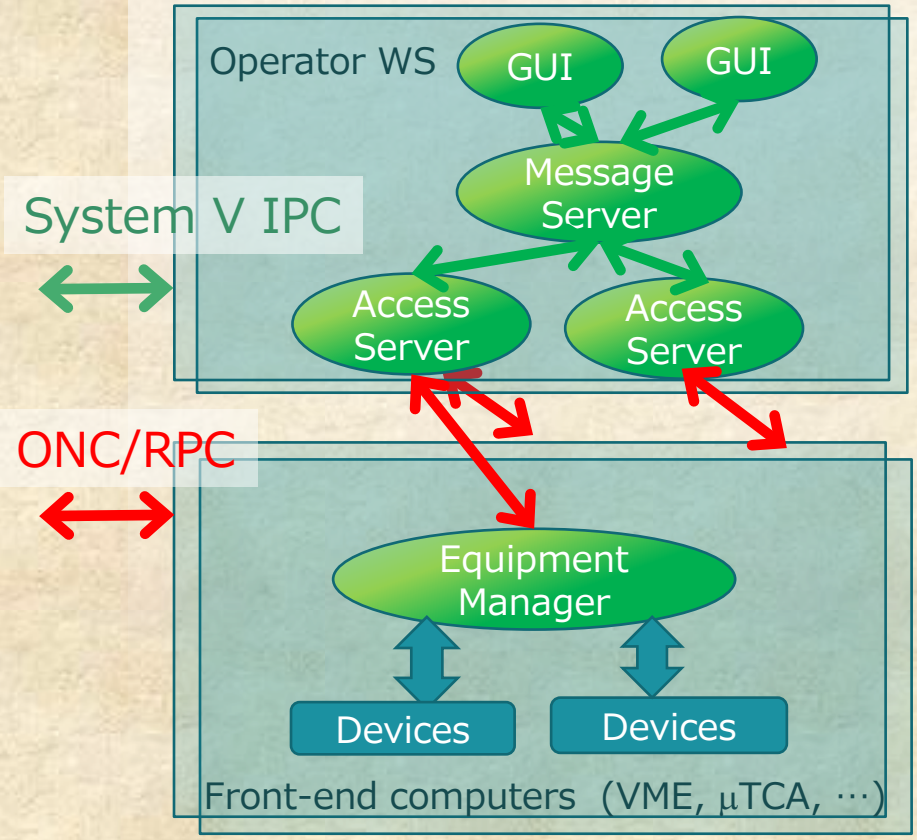

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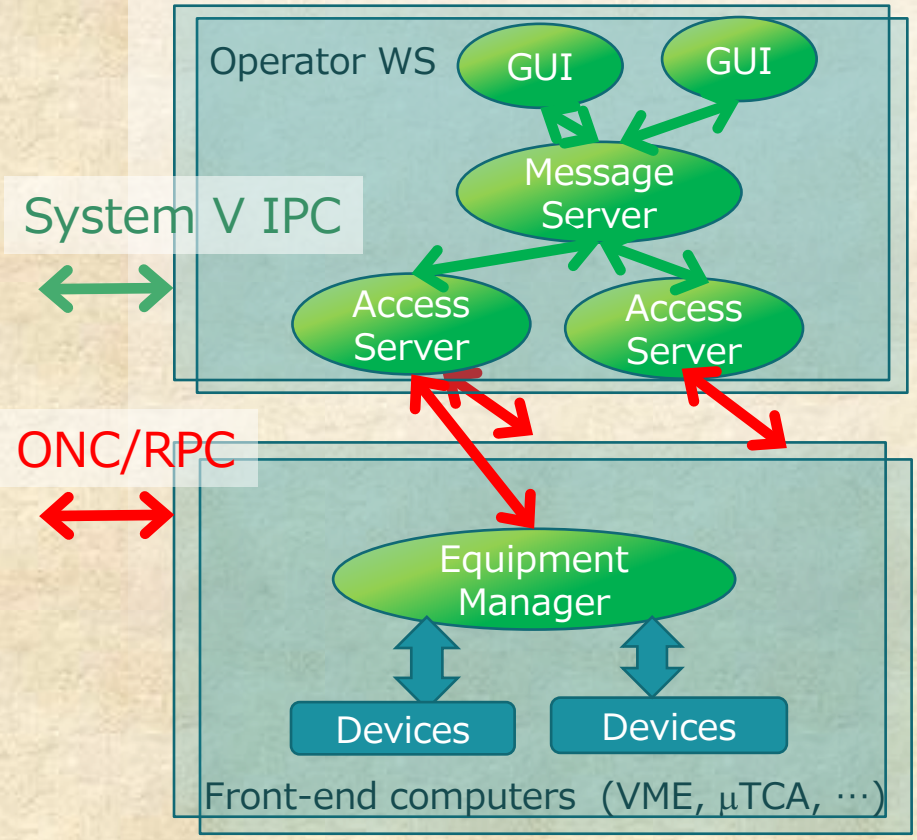

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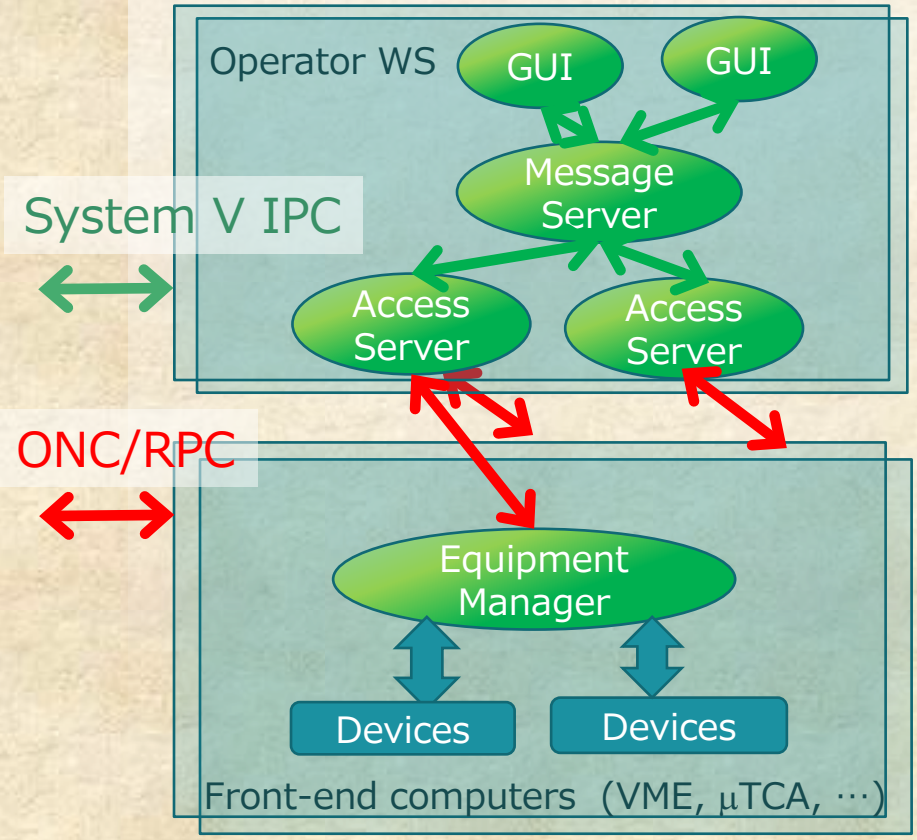

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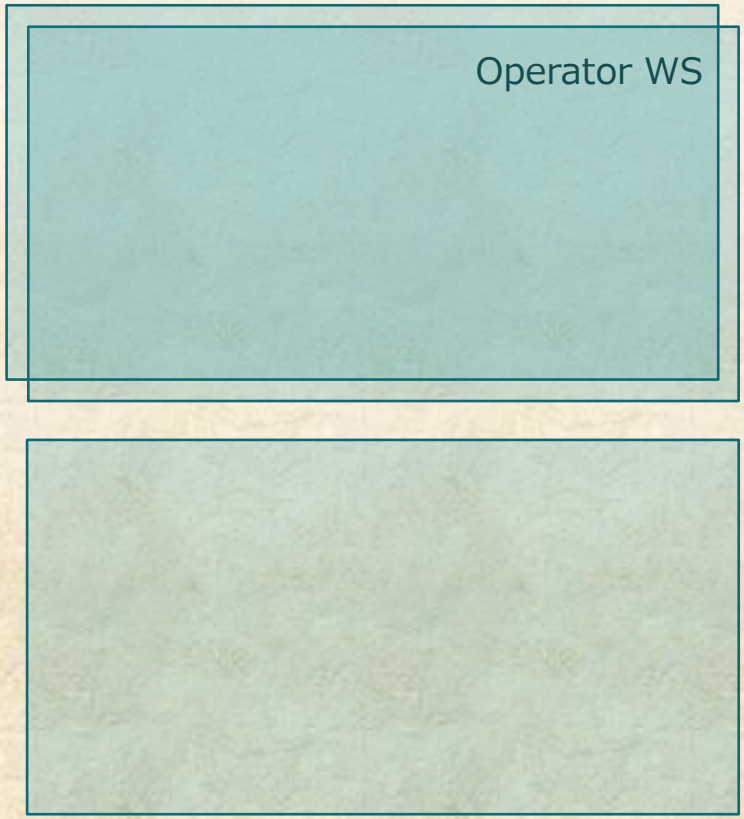

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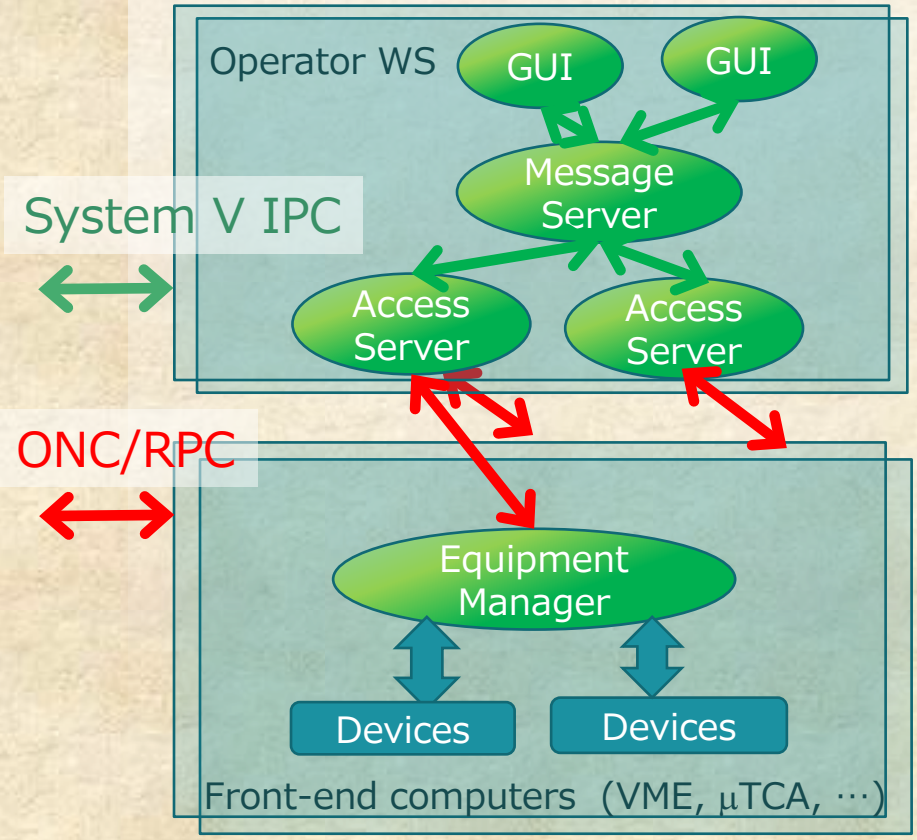

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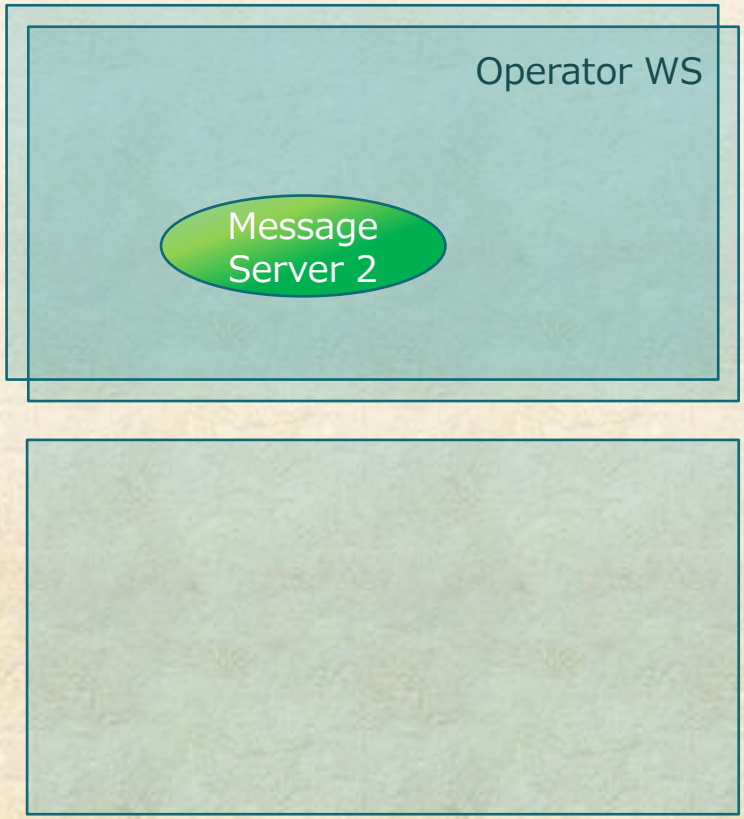

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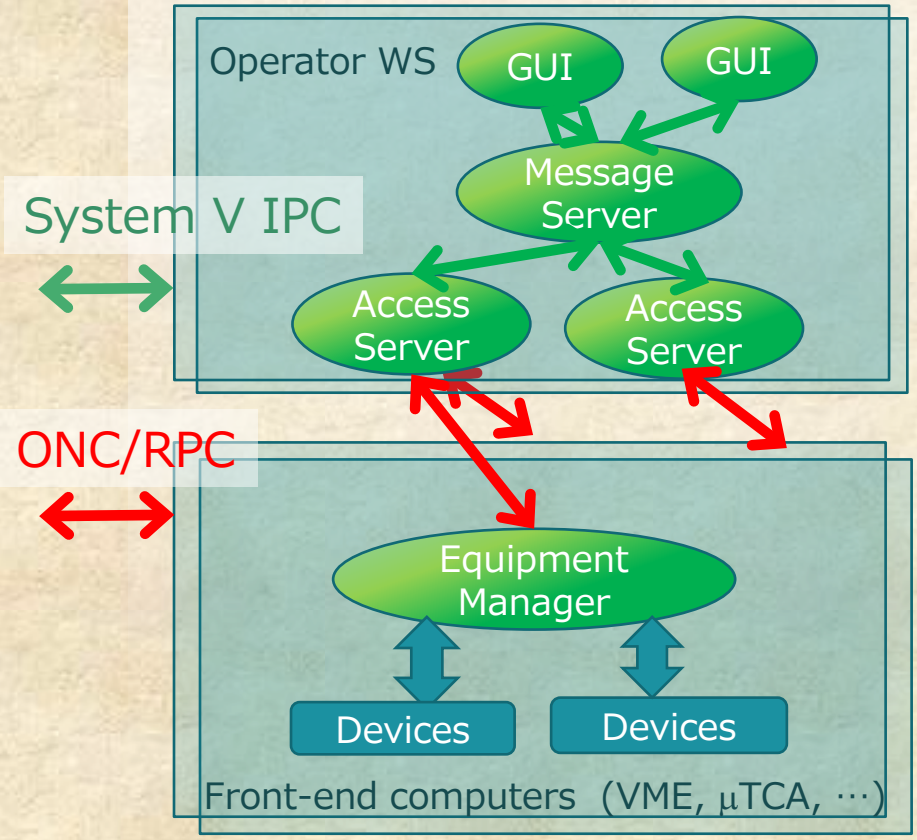

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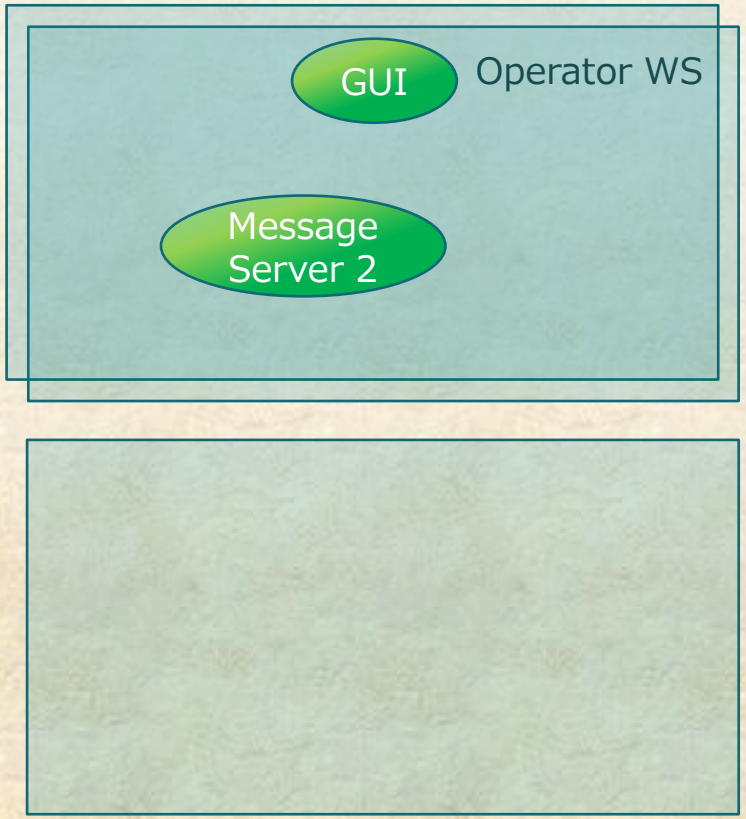

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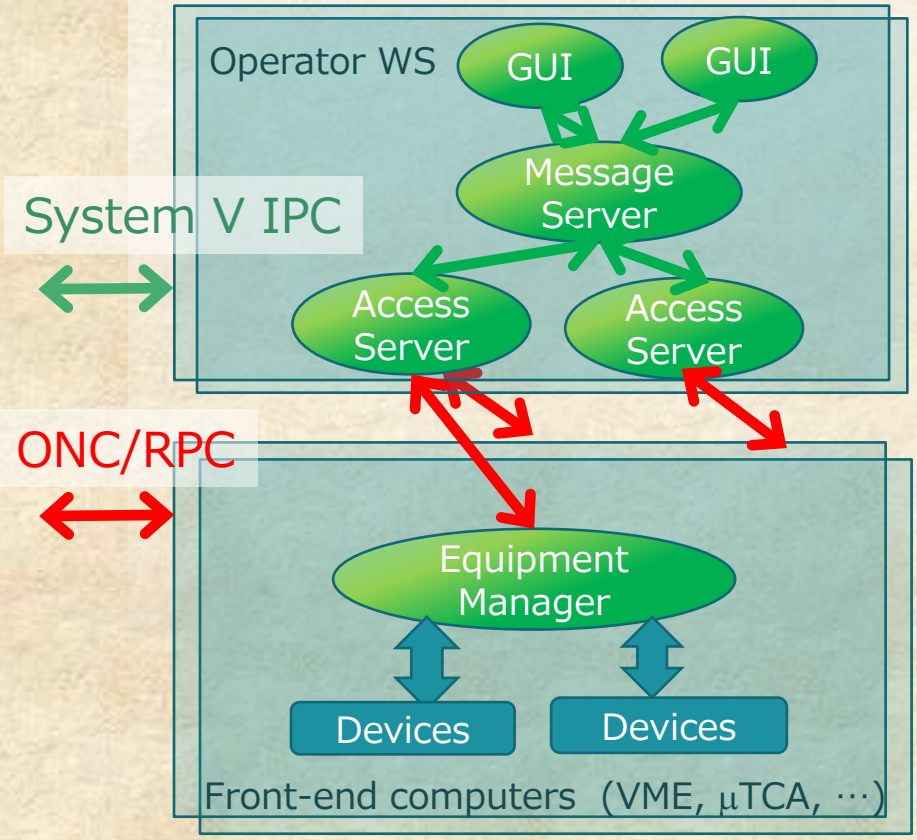

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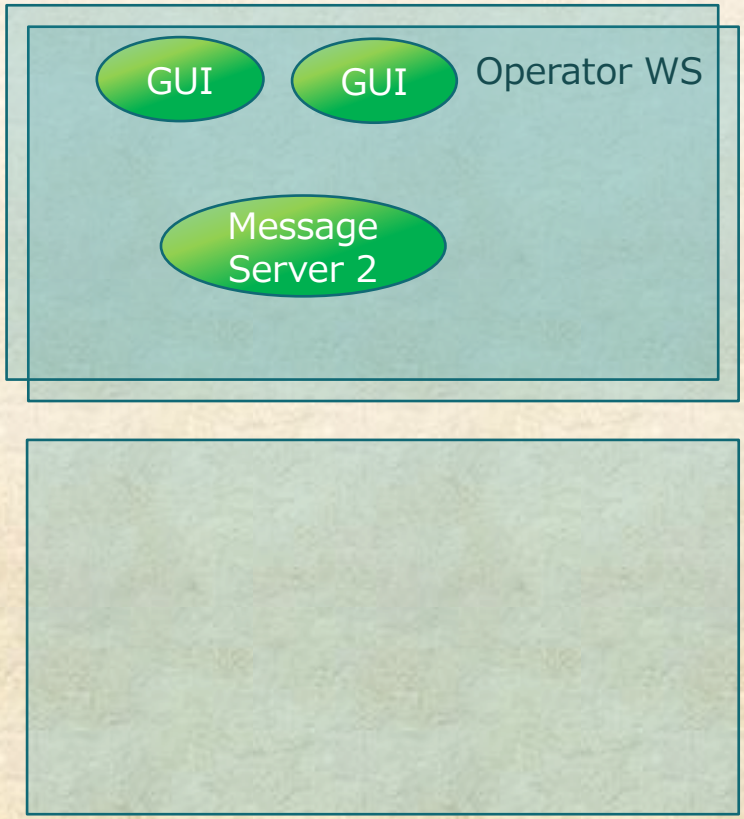

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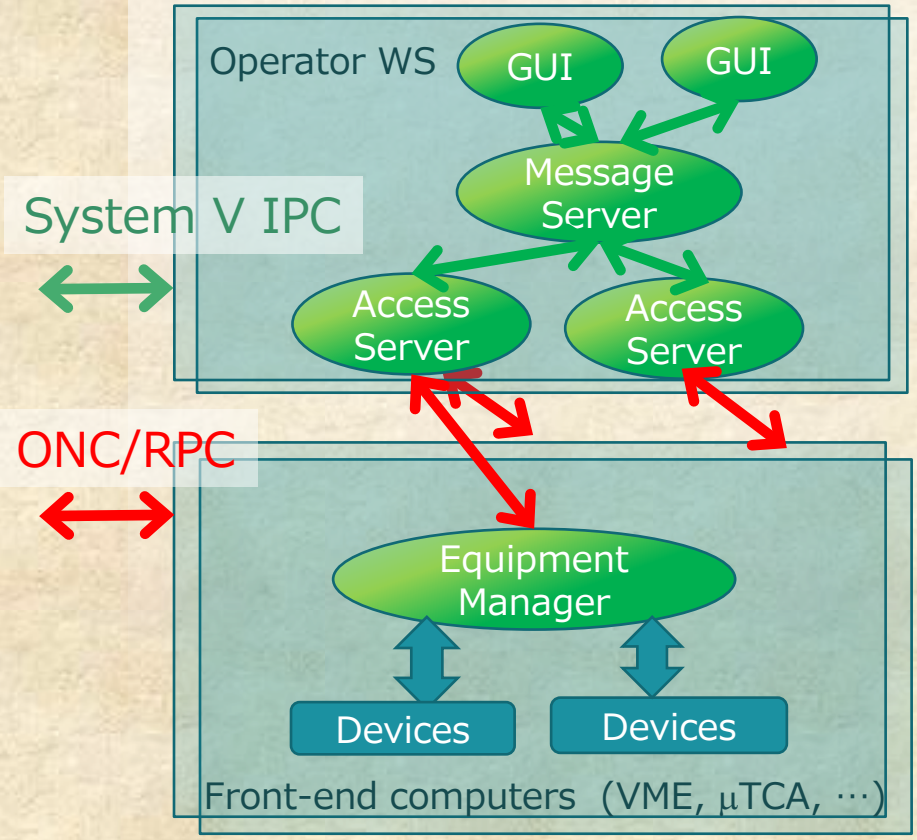

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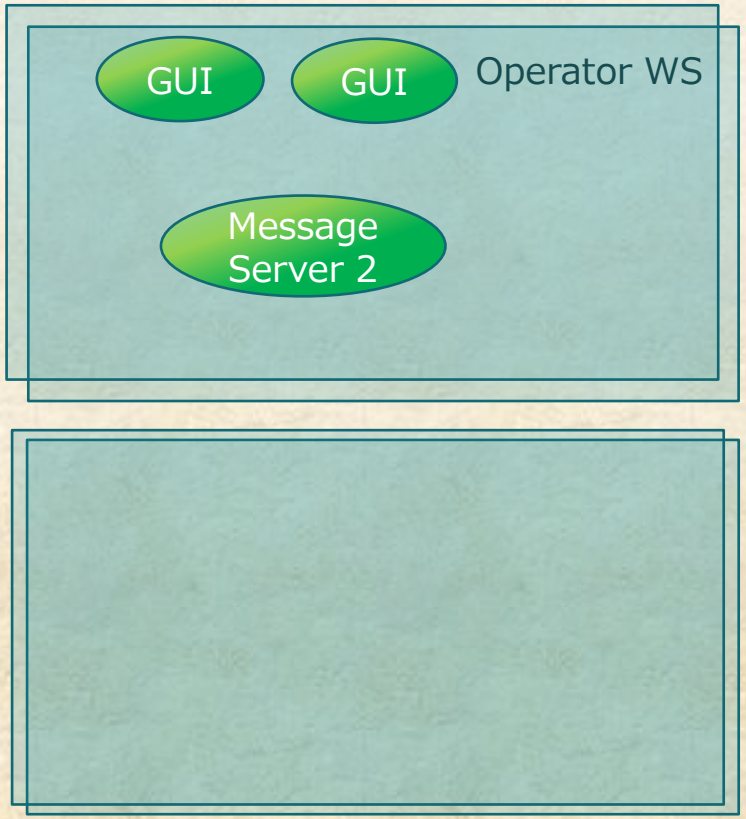

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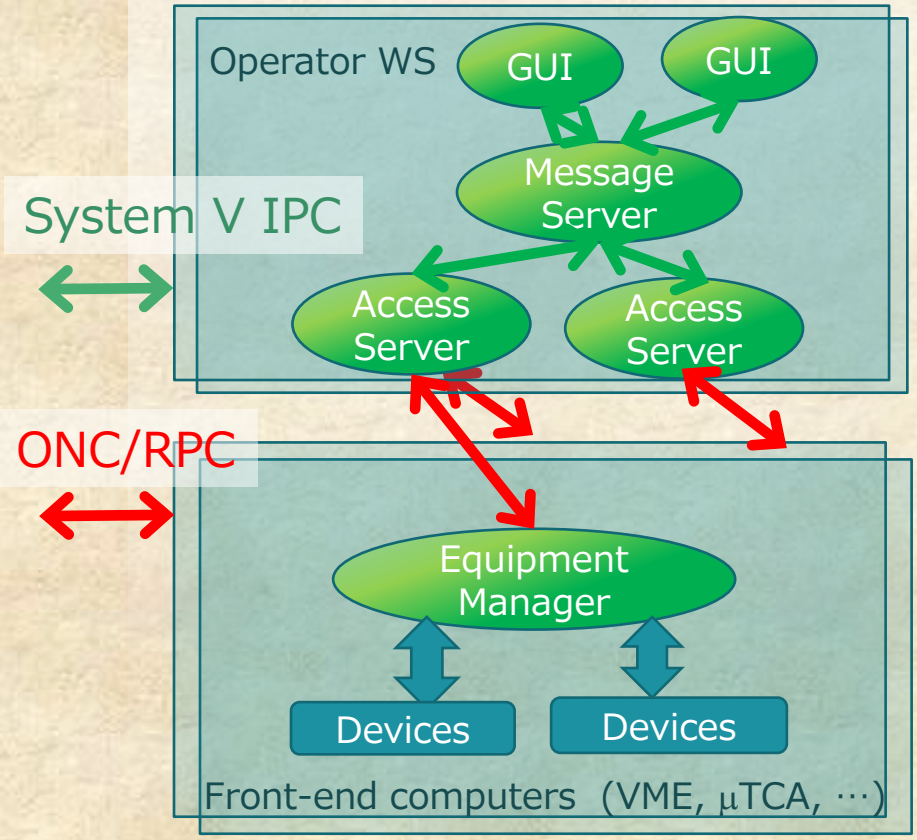

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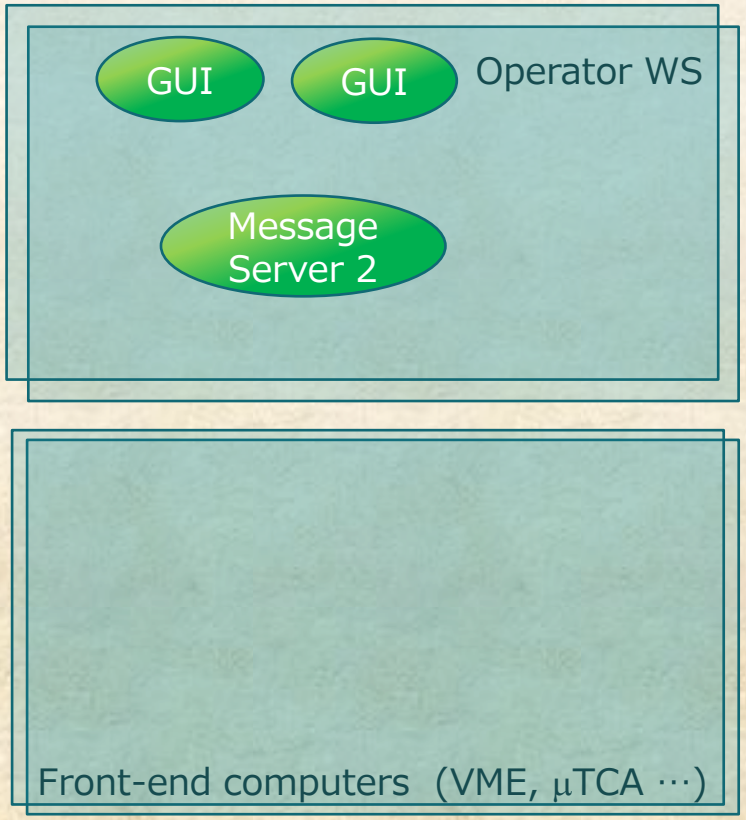

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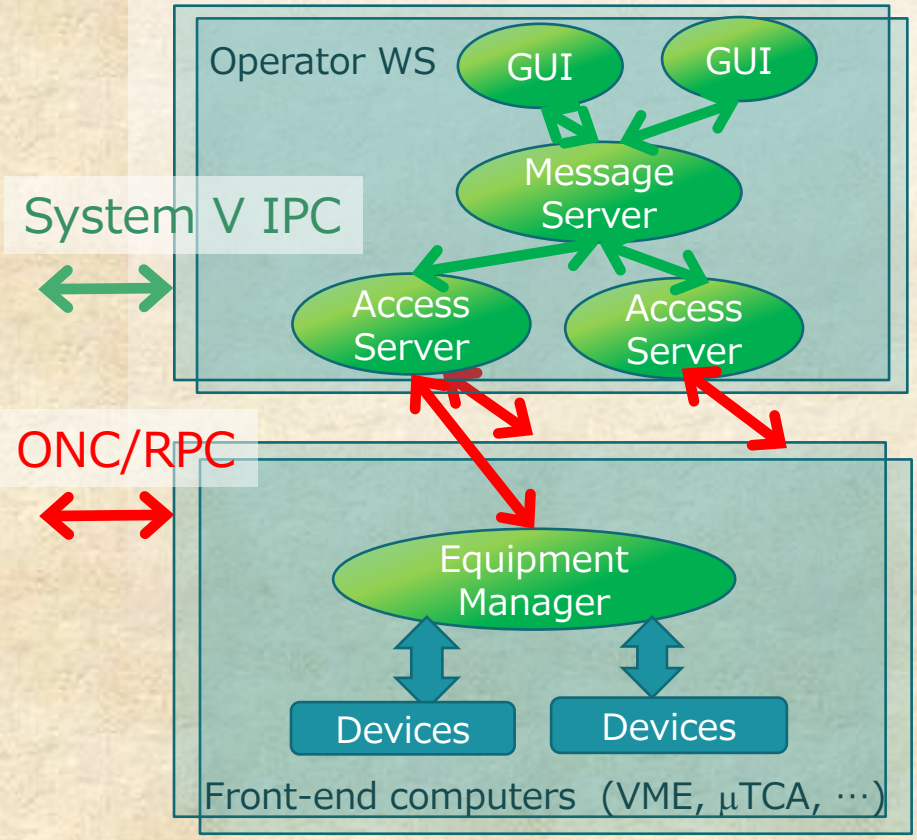

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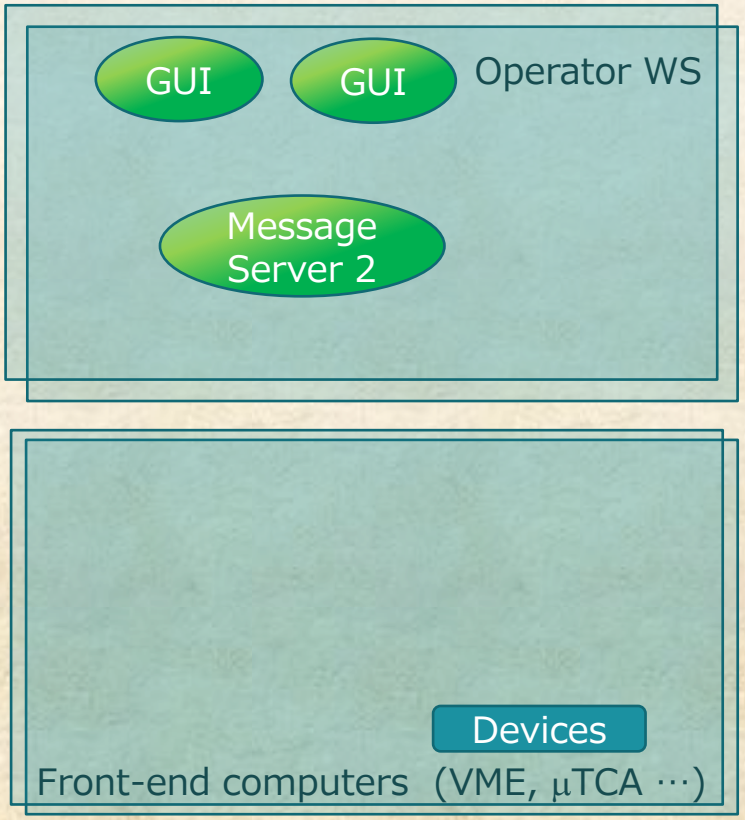

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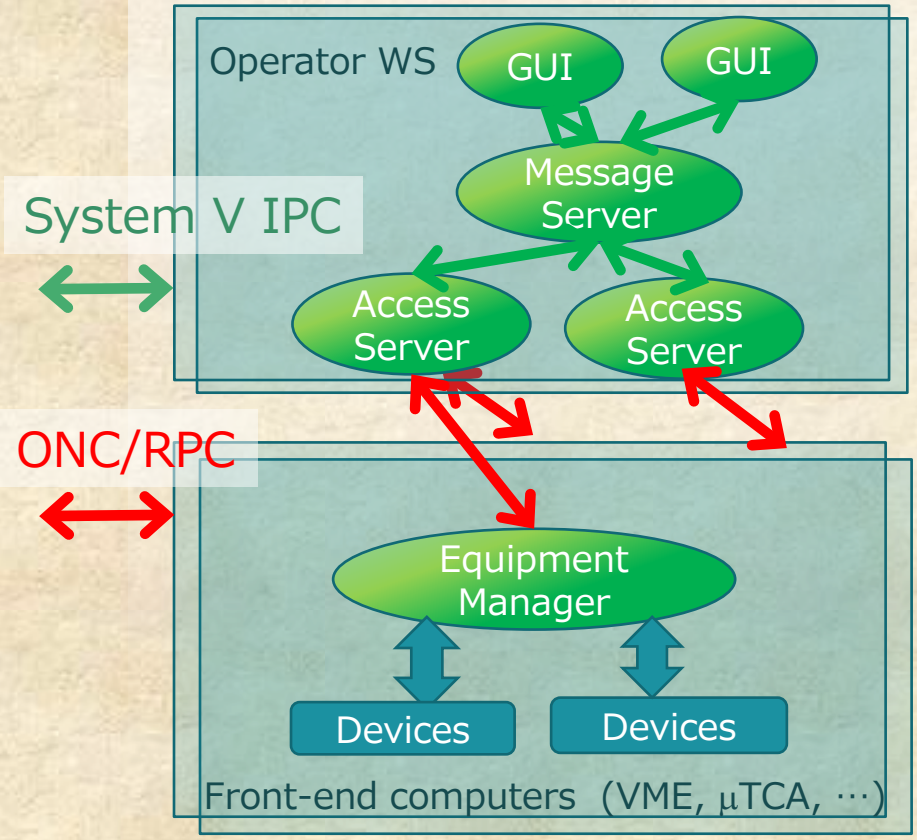

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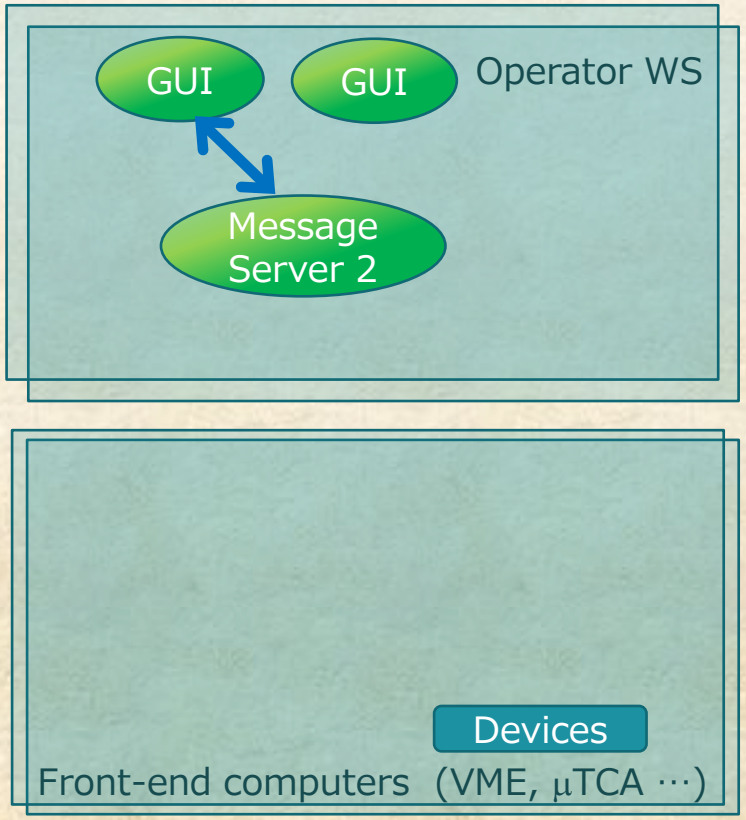

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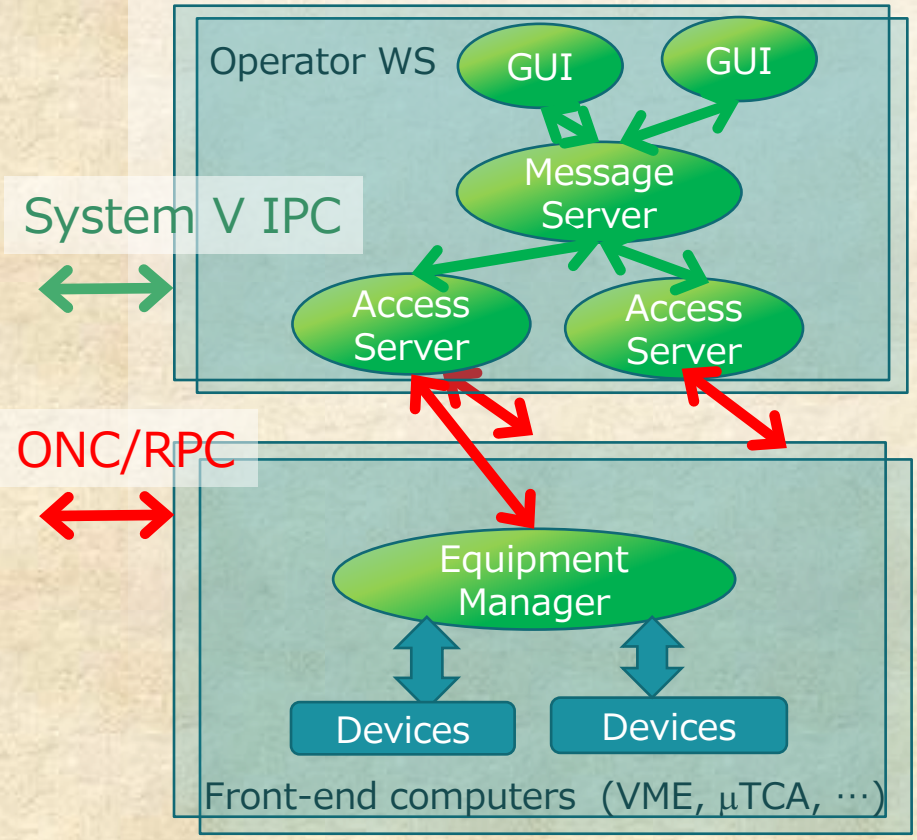

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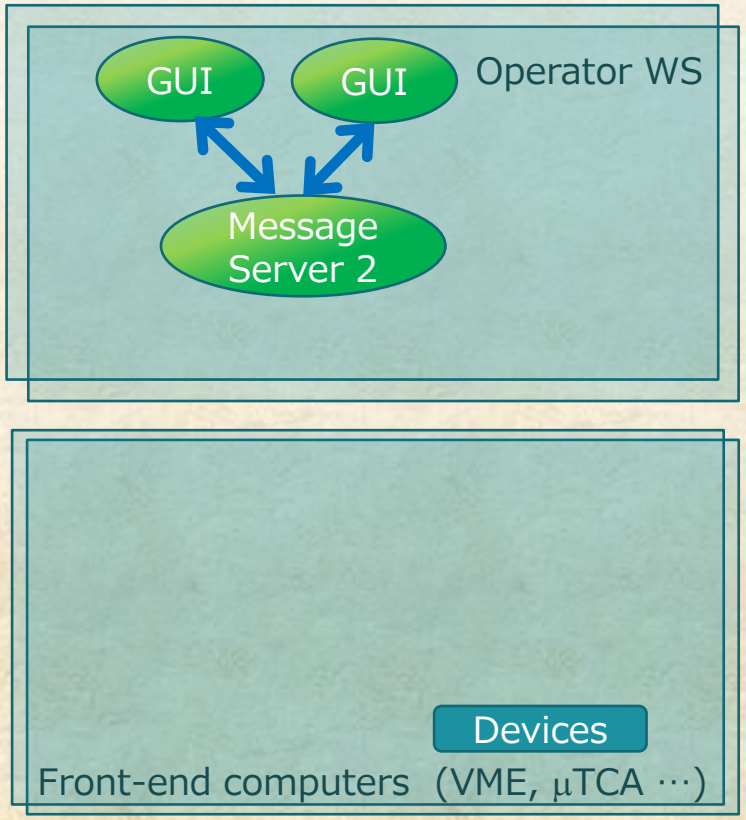

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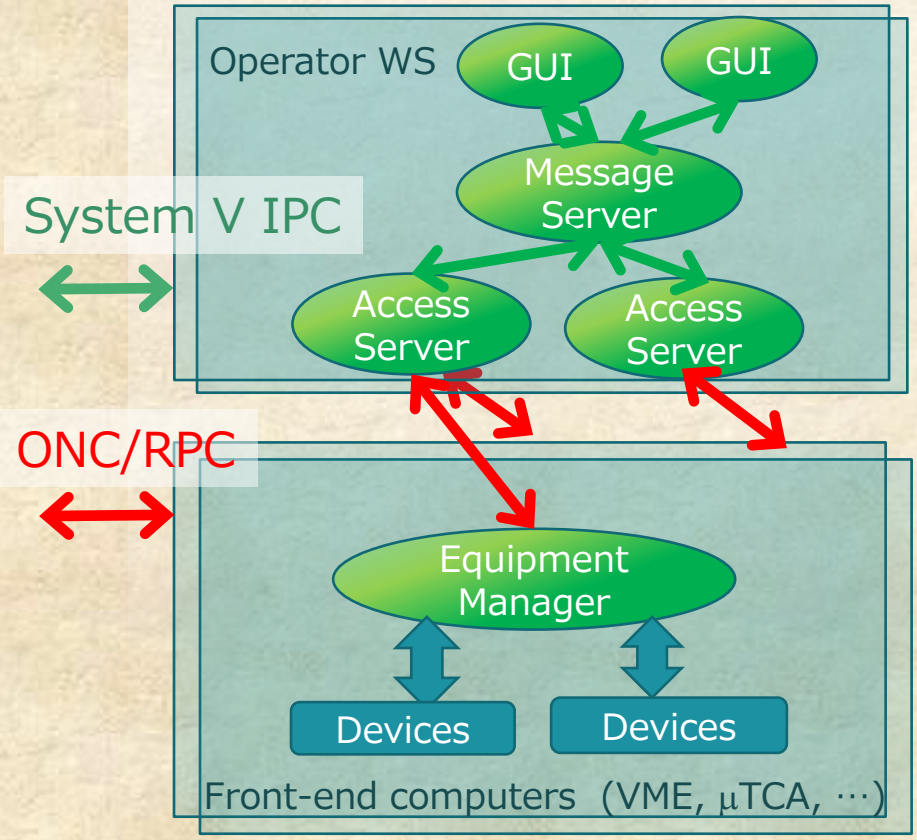

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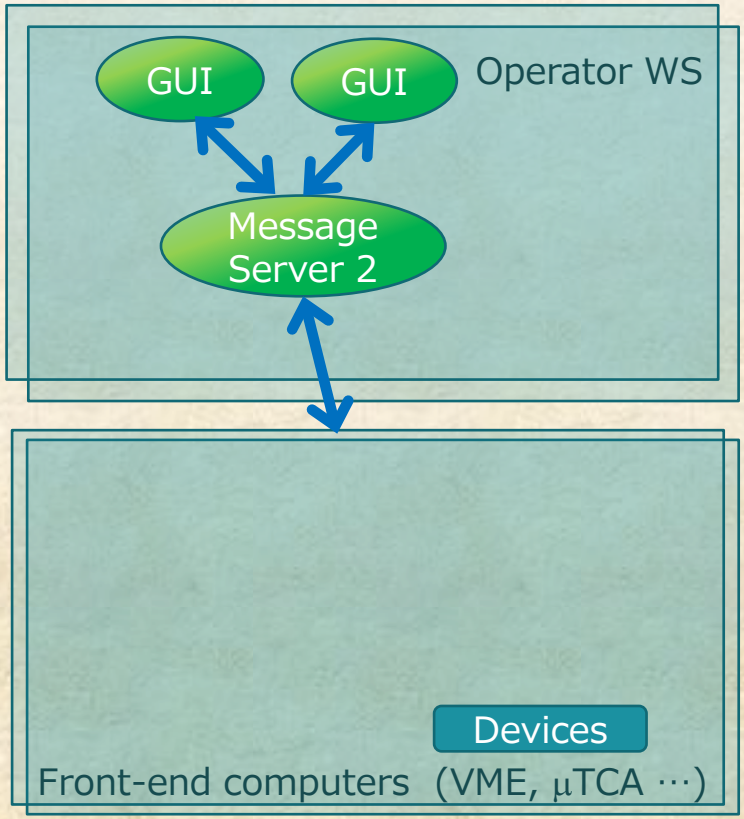

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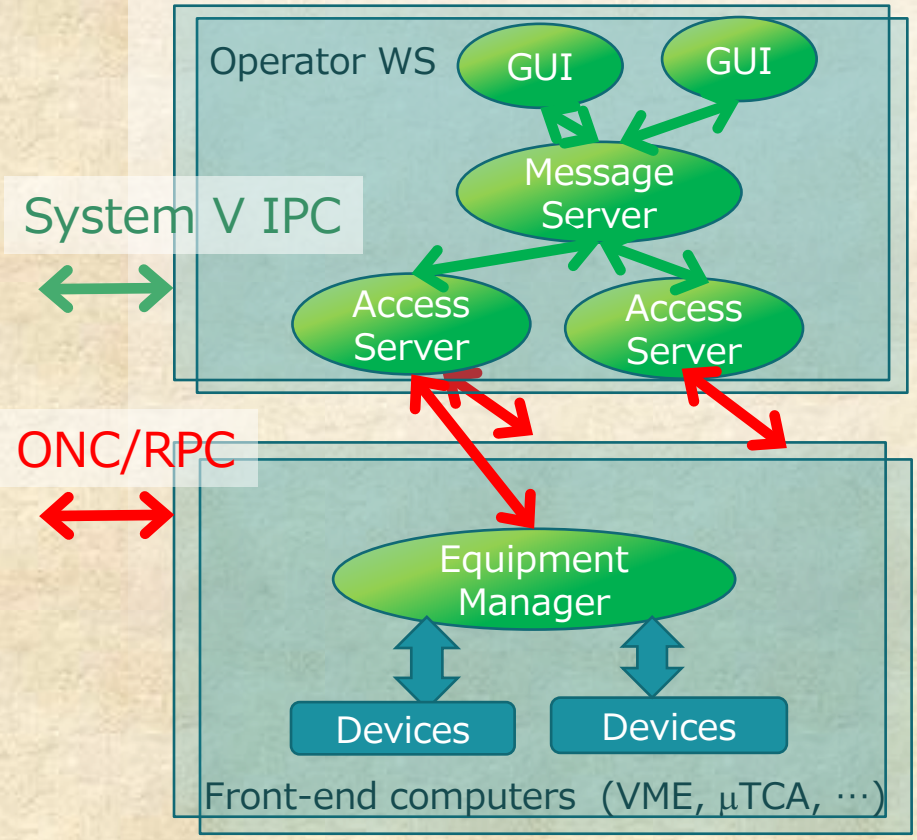

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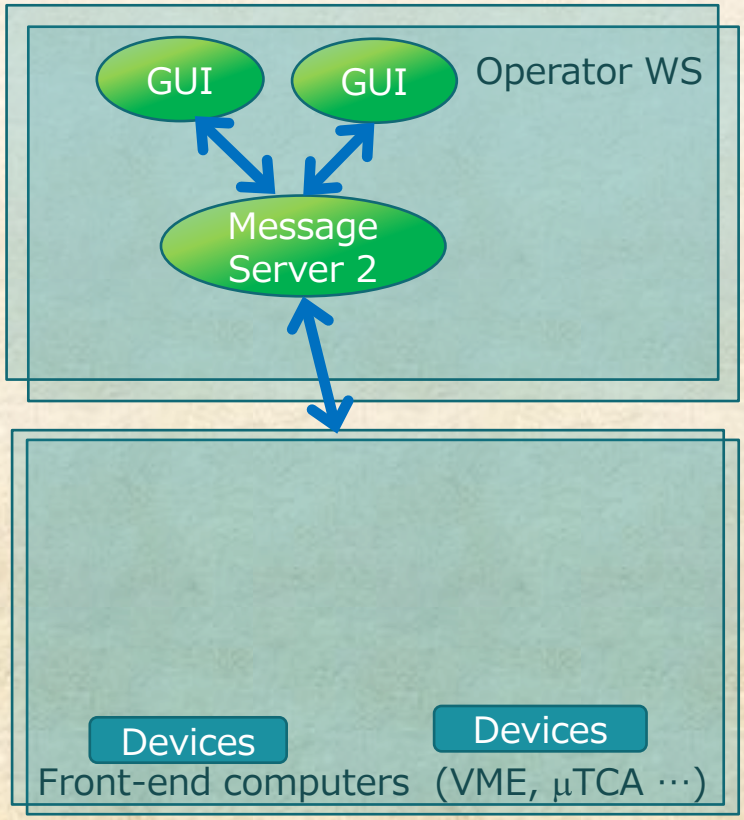

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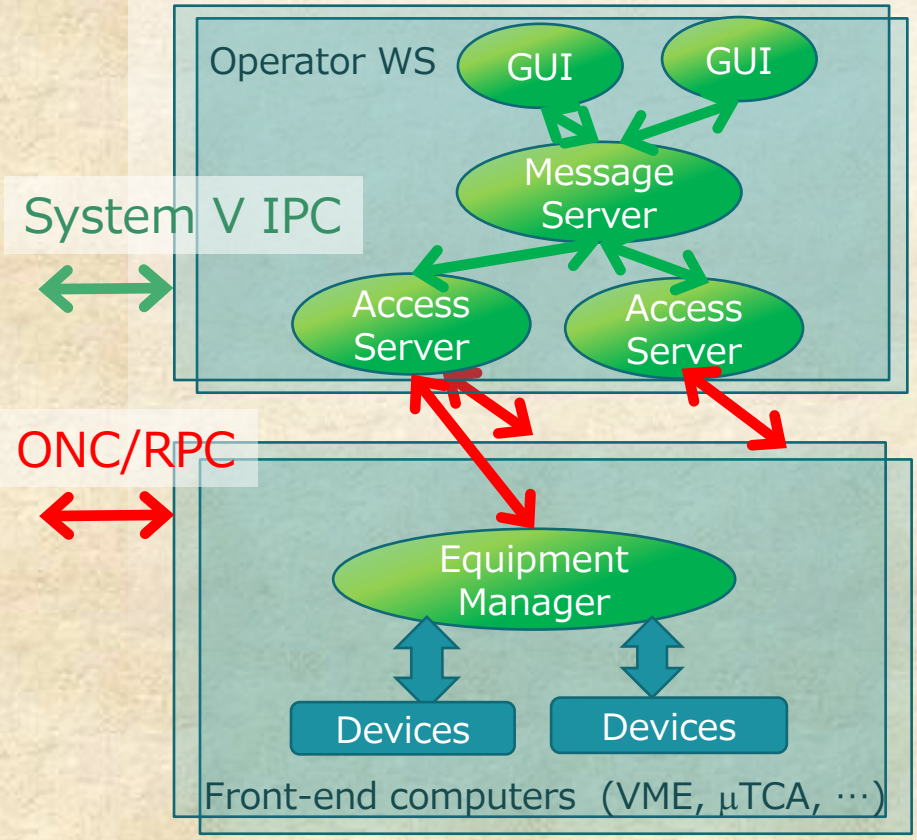

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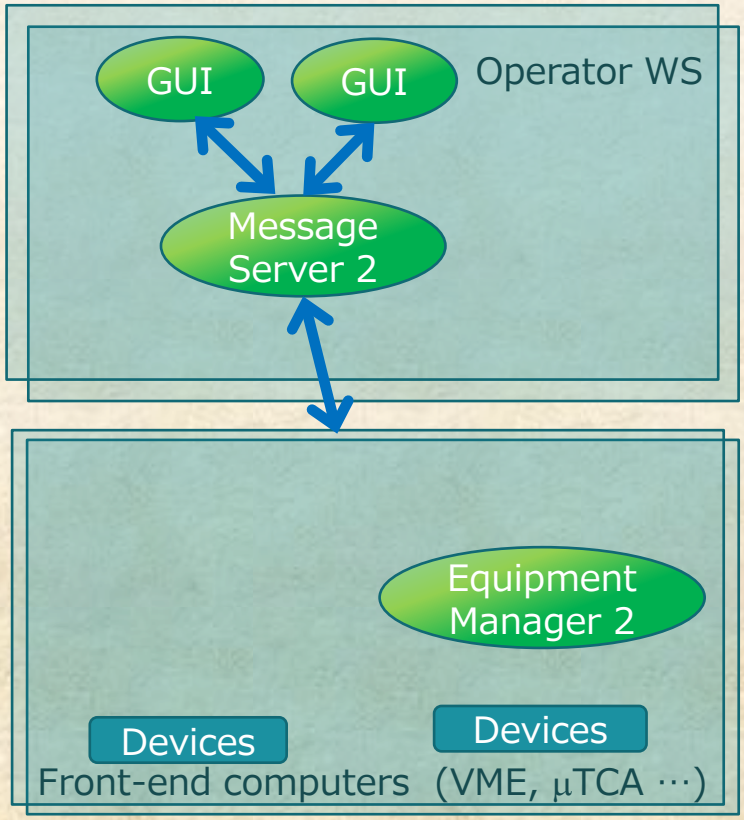

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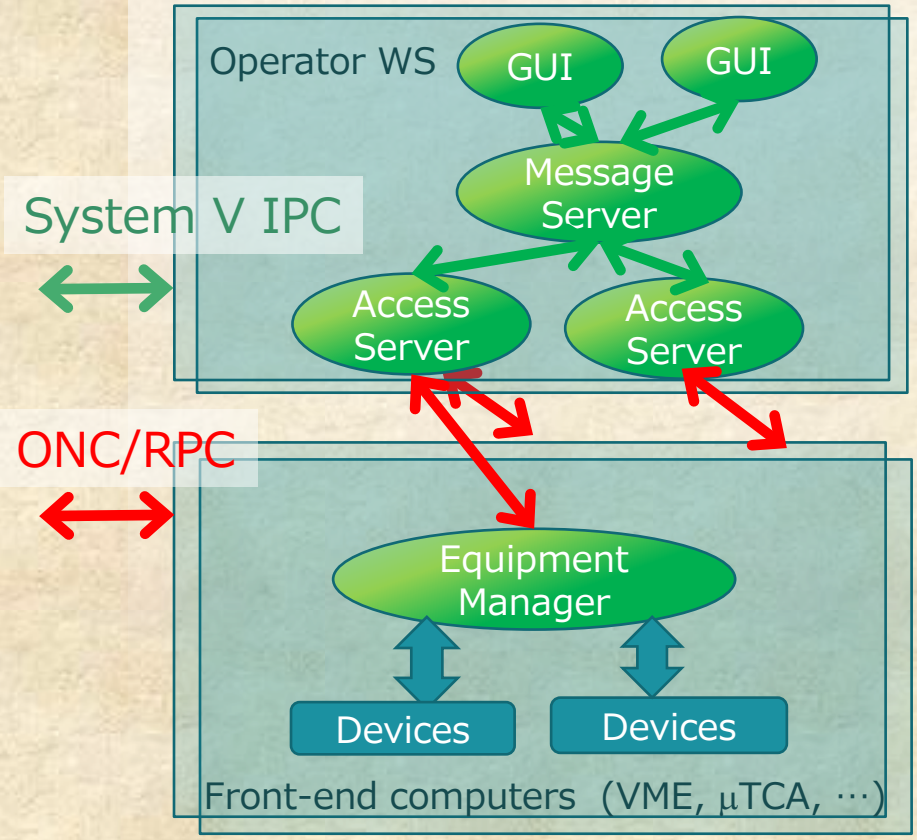

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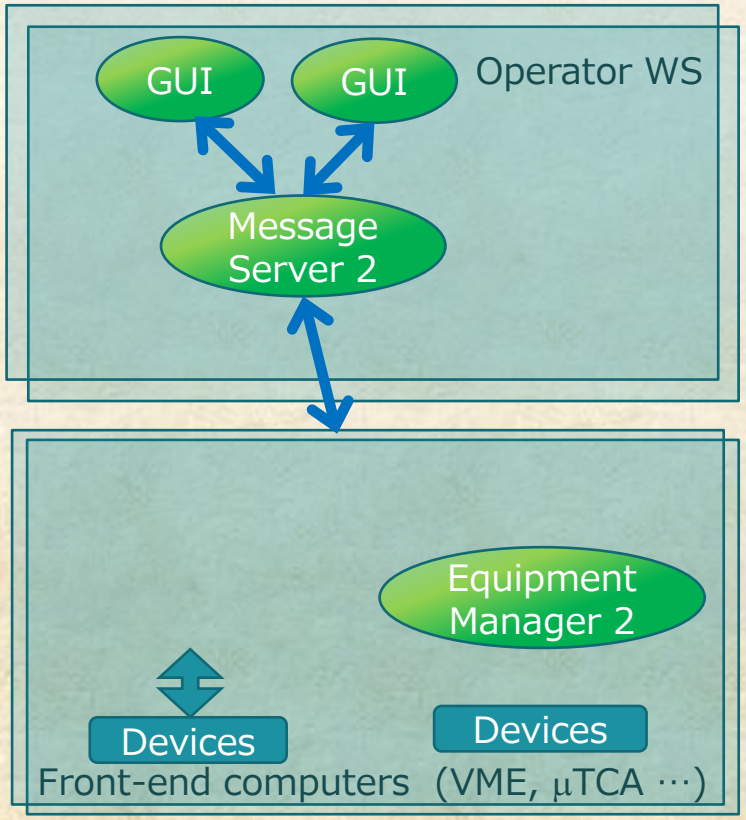

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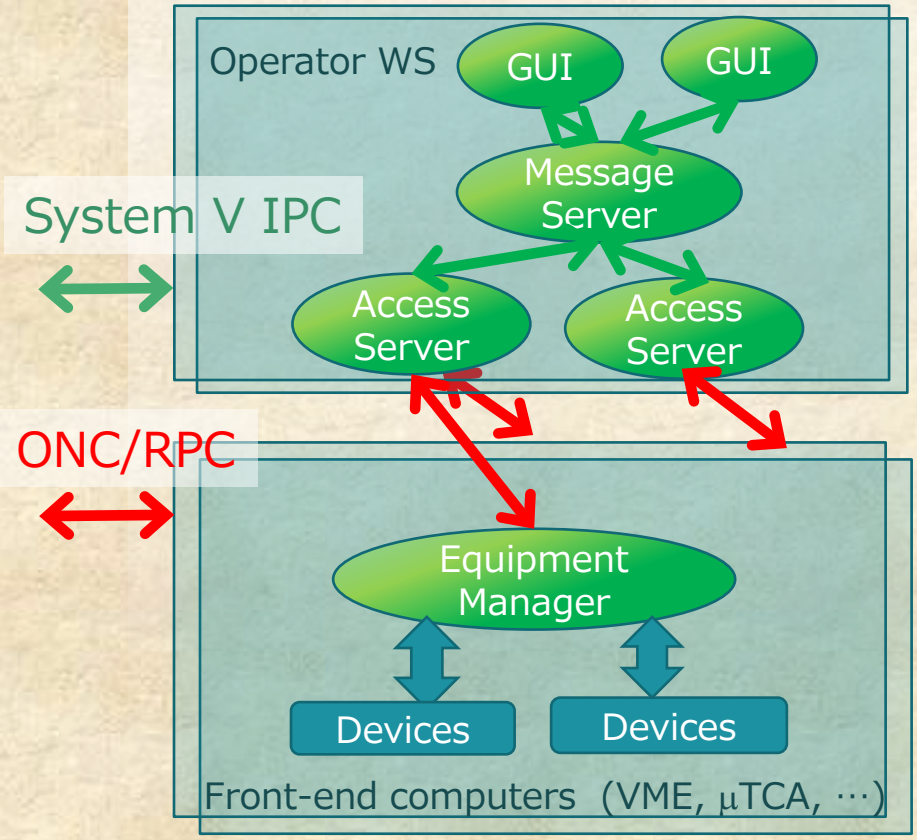

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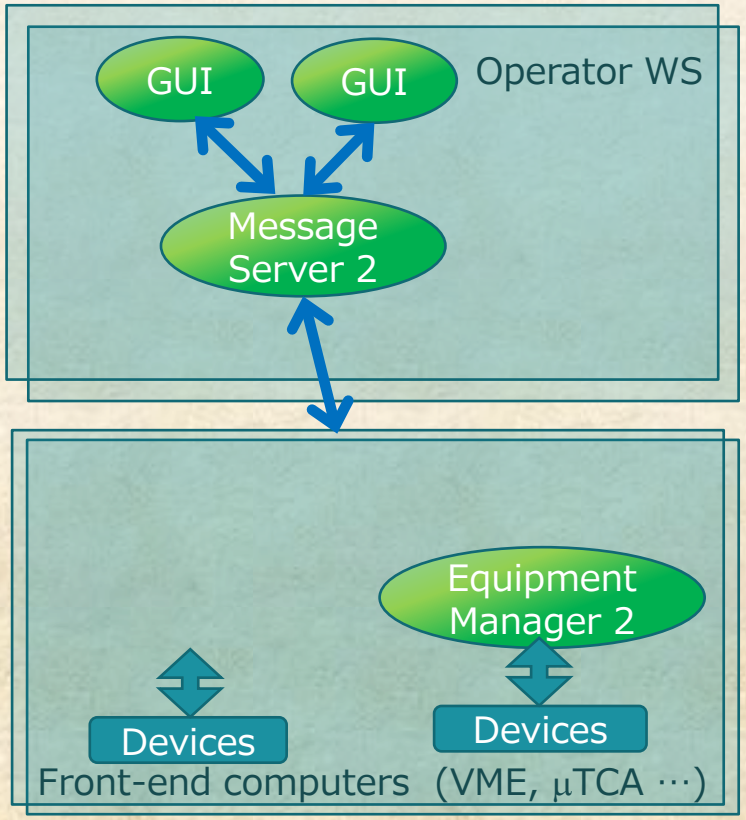

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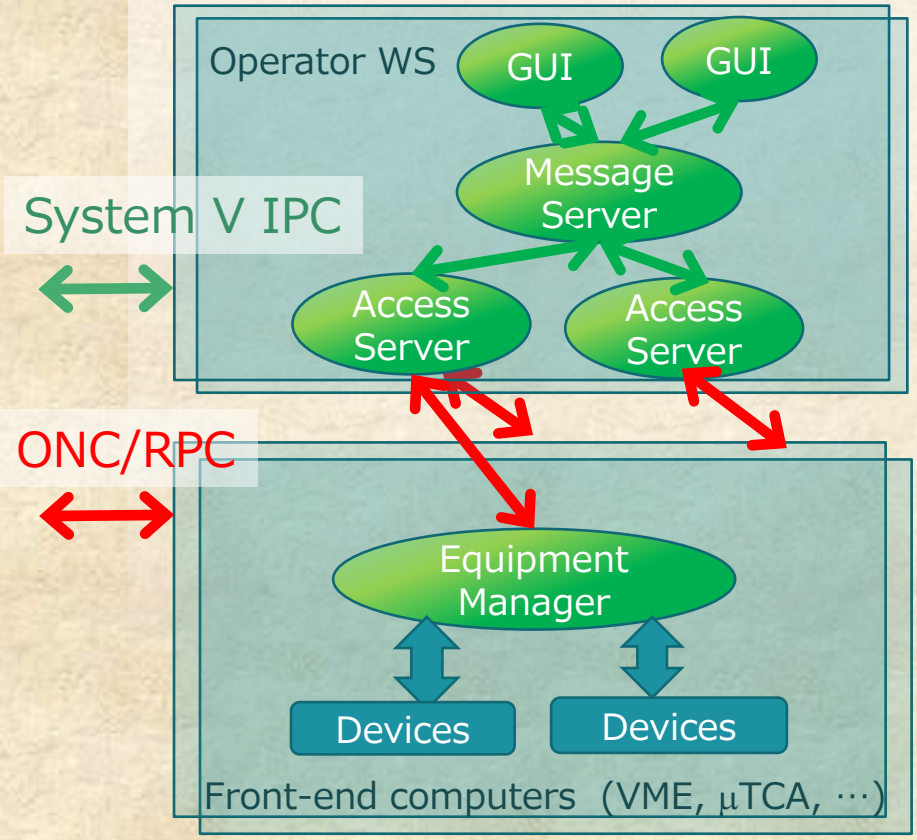

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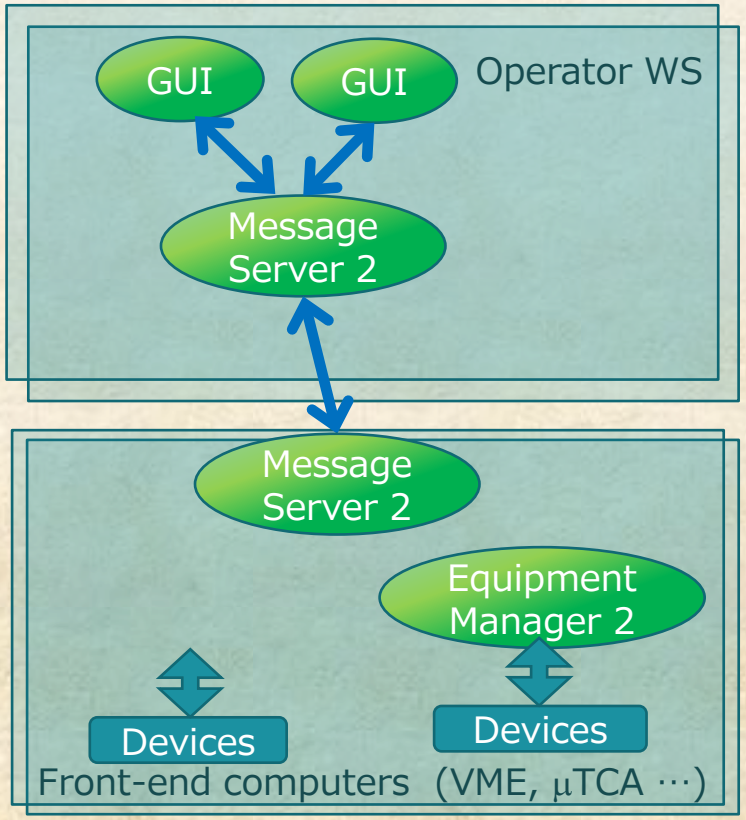

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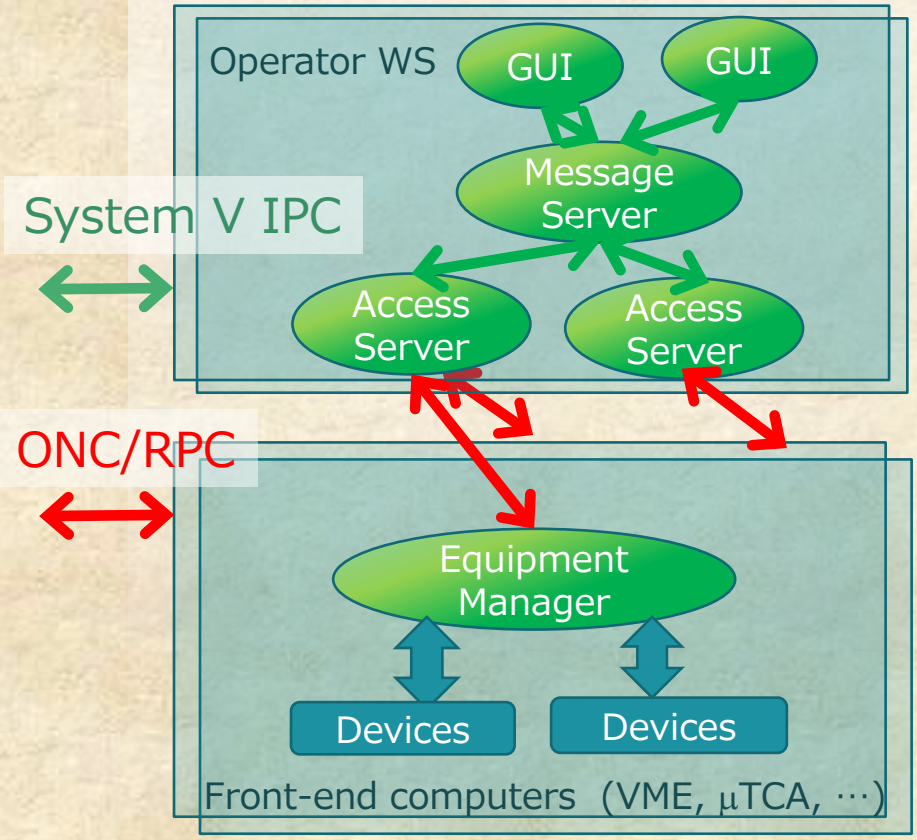

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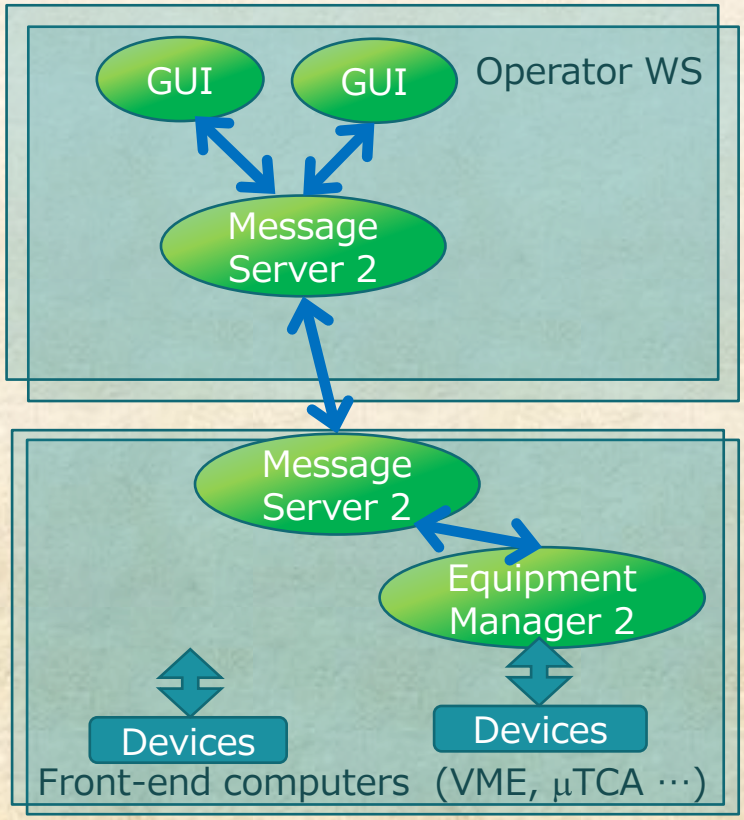

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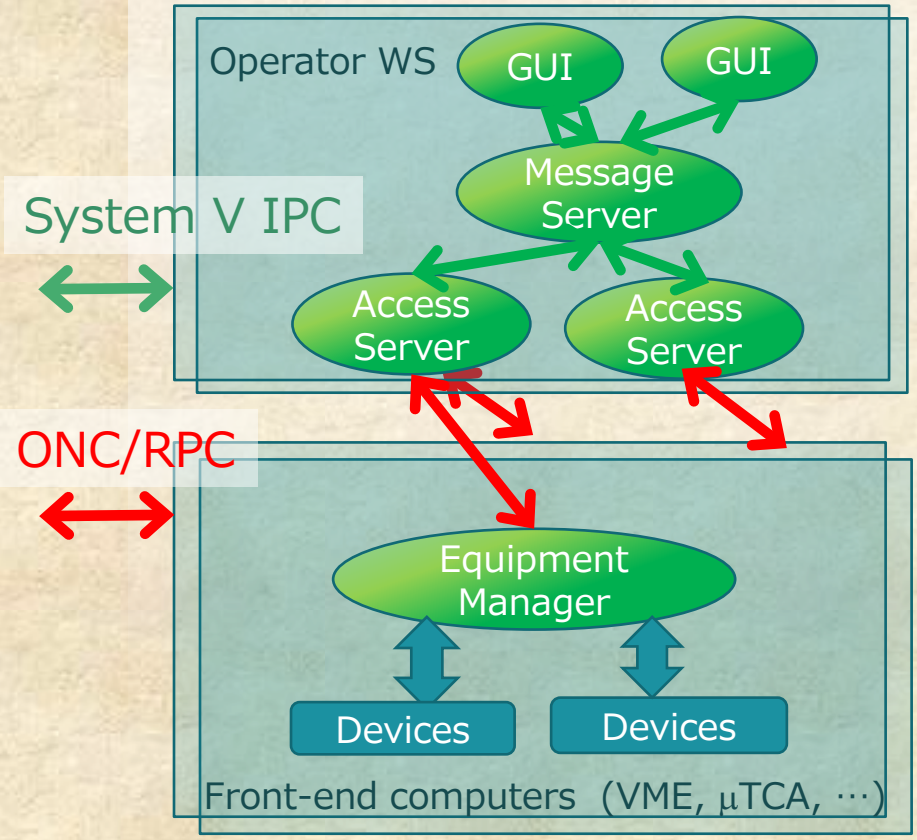

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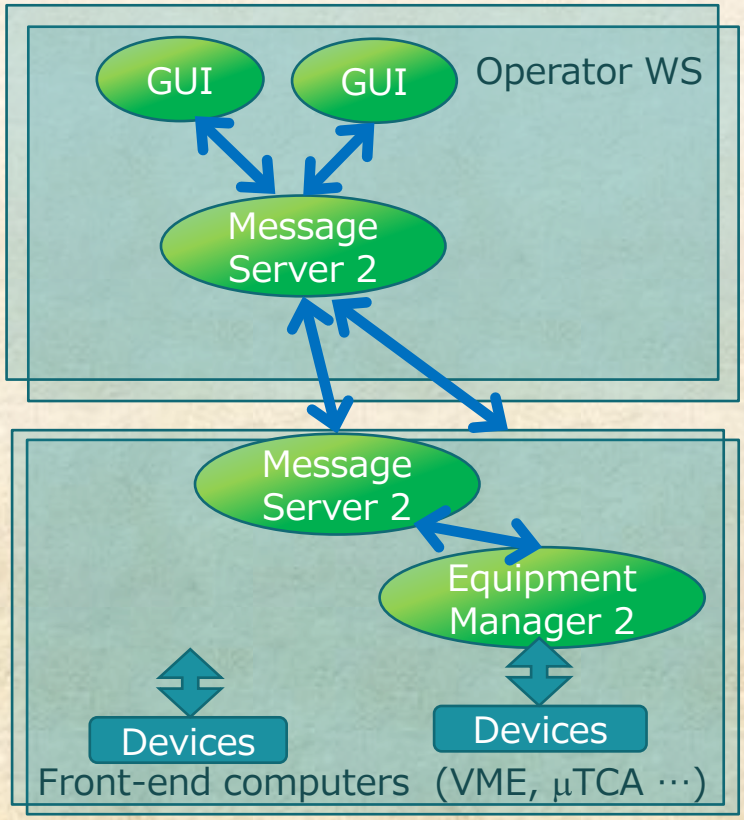

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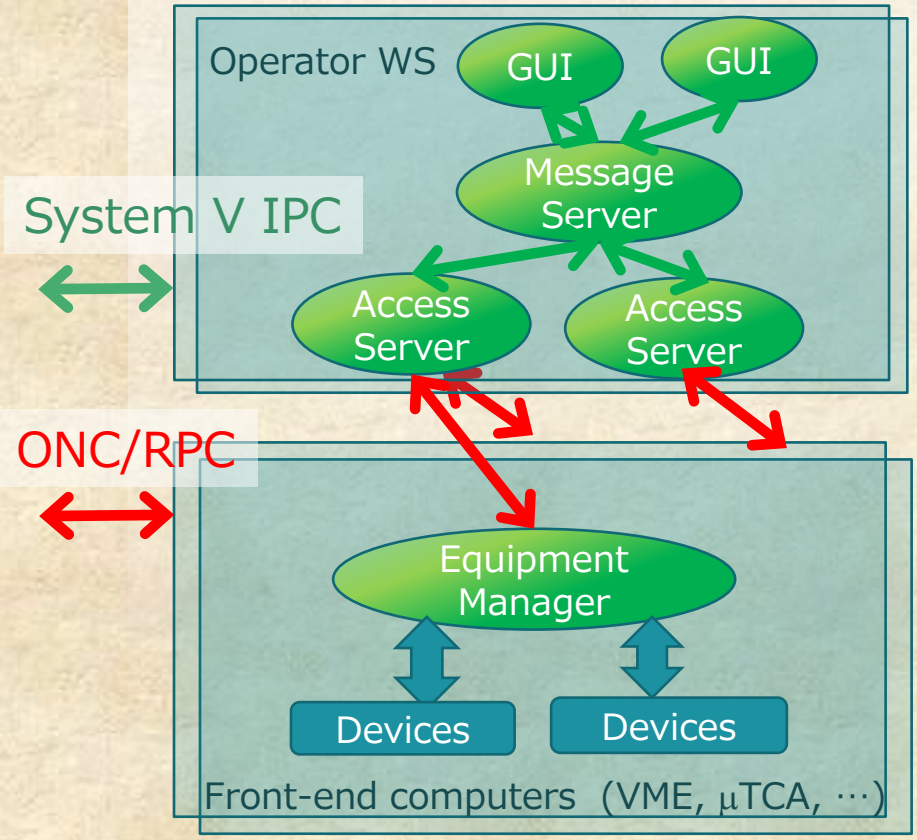

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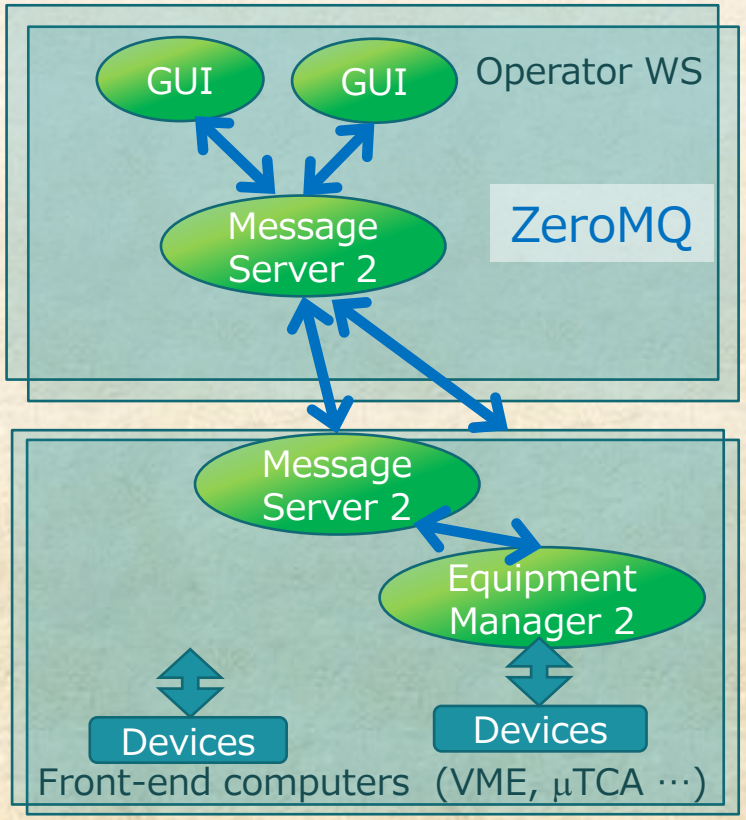

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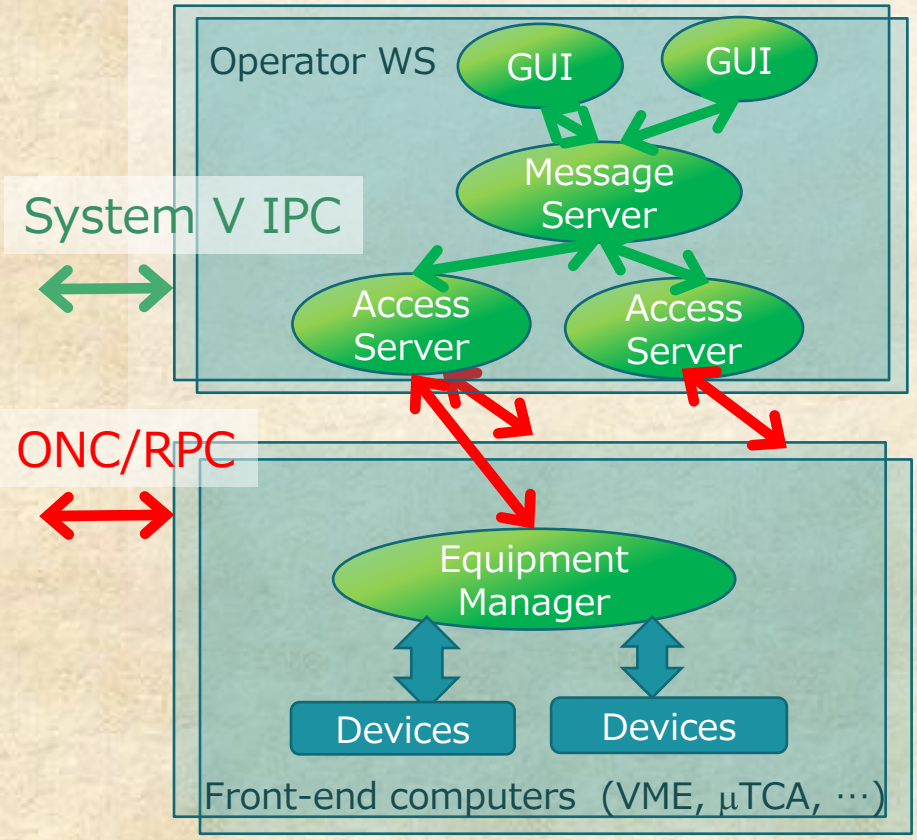

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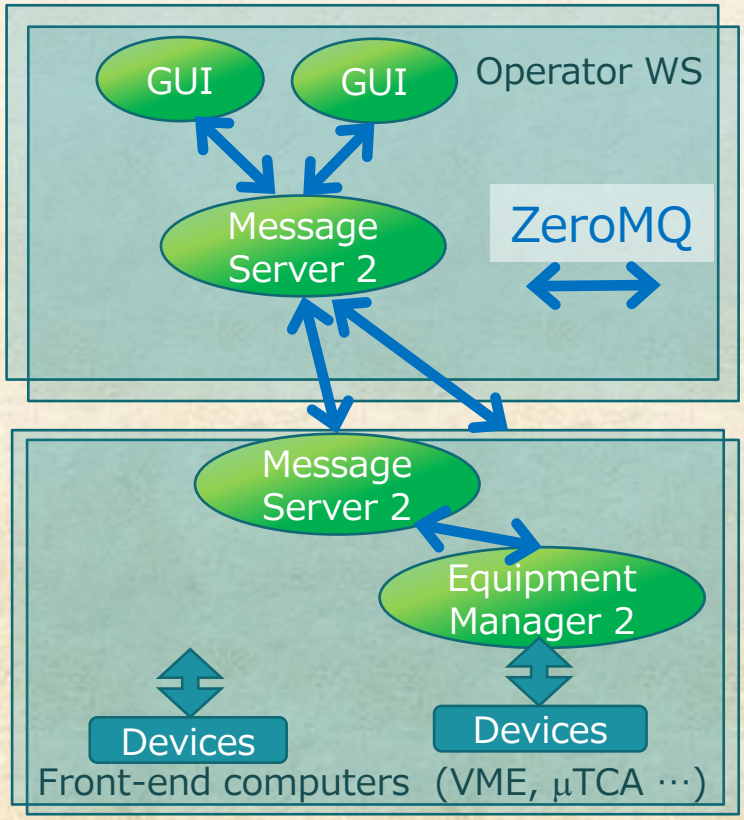
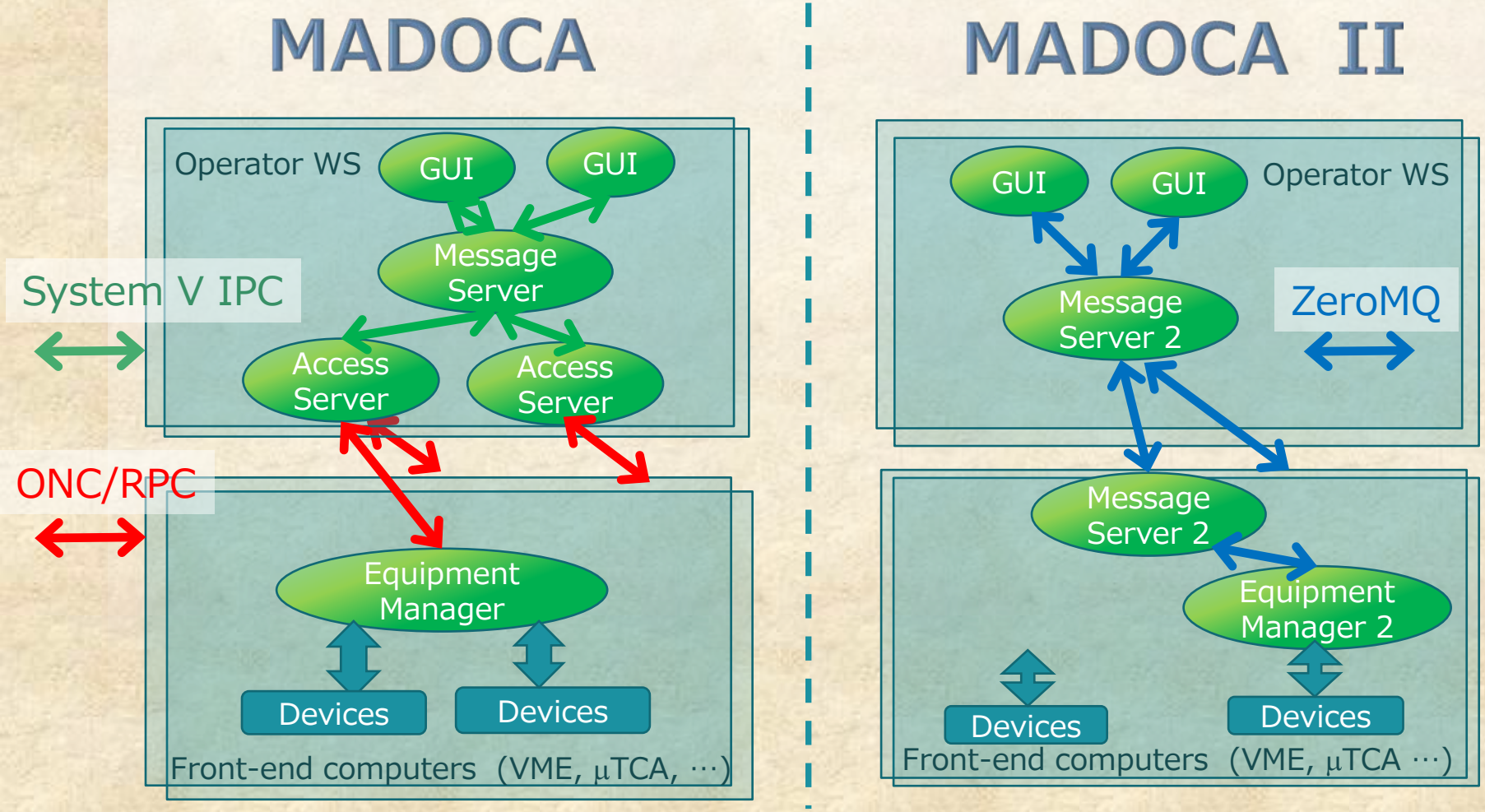
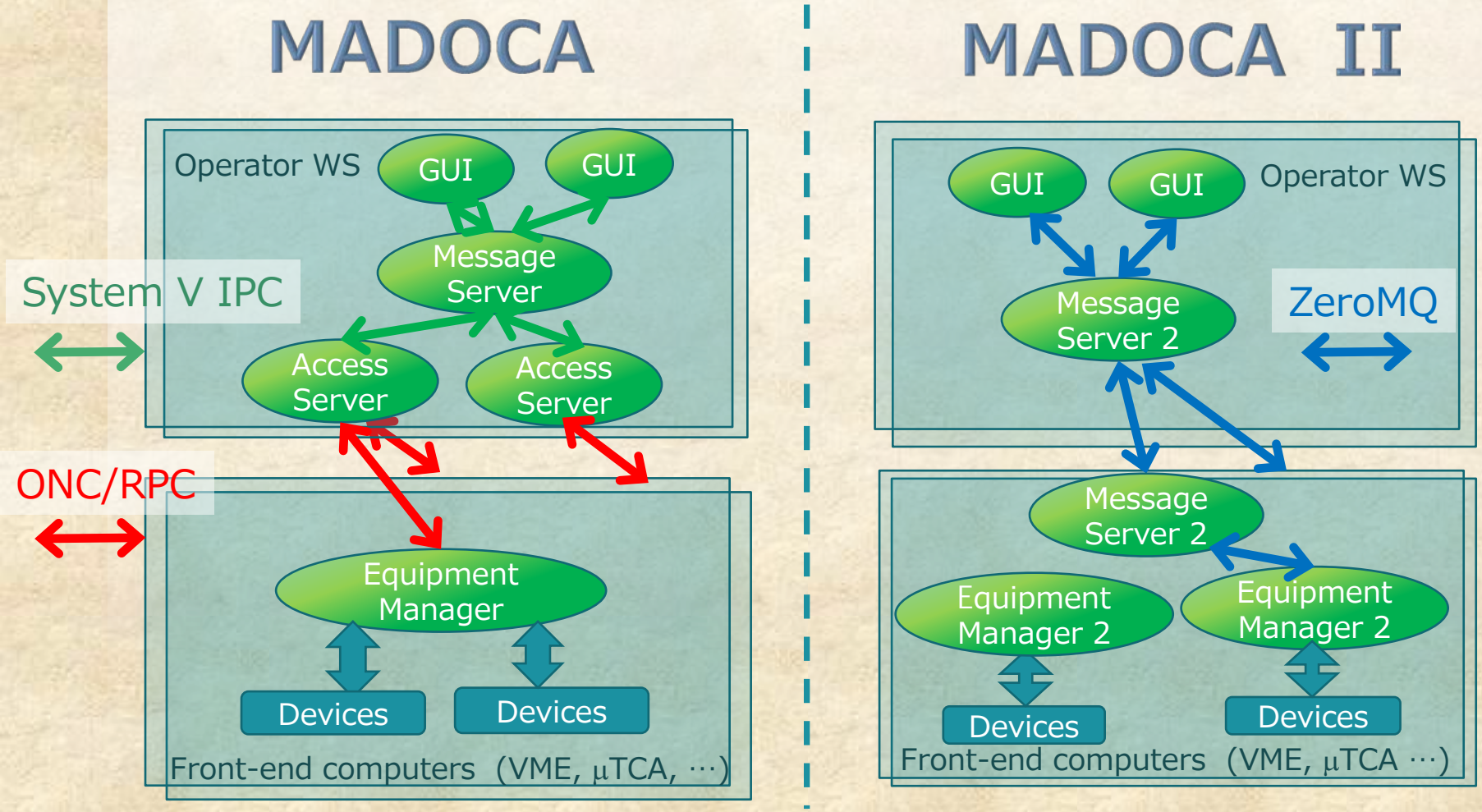



MADOCA
Operator WS
GUI
GUI
Message Server
System V IPC
Access Server
Access Server
ONC/RPC
Equipment Manager
Devices
Devices
Front-end computers (VME, μTCA, ⋯)
MADOCA II
GUI
GUI
Operator WS
Message Server 2
ZeroMQ
Message Server 2
Equipment Manager 2
Devices
Devices
Front-end computers (VME, μTCA ⋯)


MADOCA
Operator WS
GUI
GUI
Message Server
System V IPC
Access Server
Access Server
ONC/RPC
Equipment Manager
Devices
Devices
Front-end computers (VME, μTCA, ⋯)
MADOCA II
GUI
GUI
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ZeroMQ
Message Server 2
Equipment Manager 2
Equipment Manager 2
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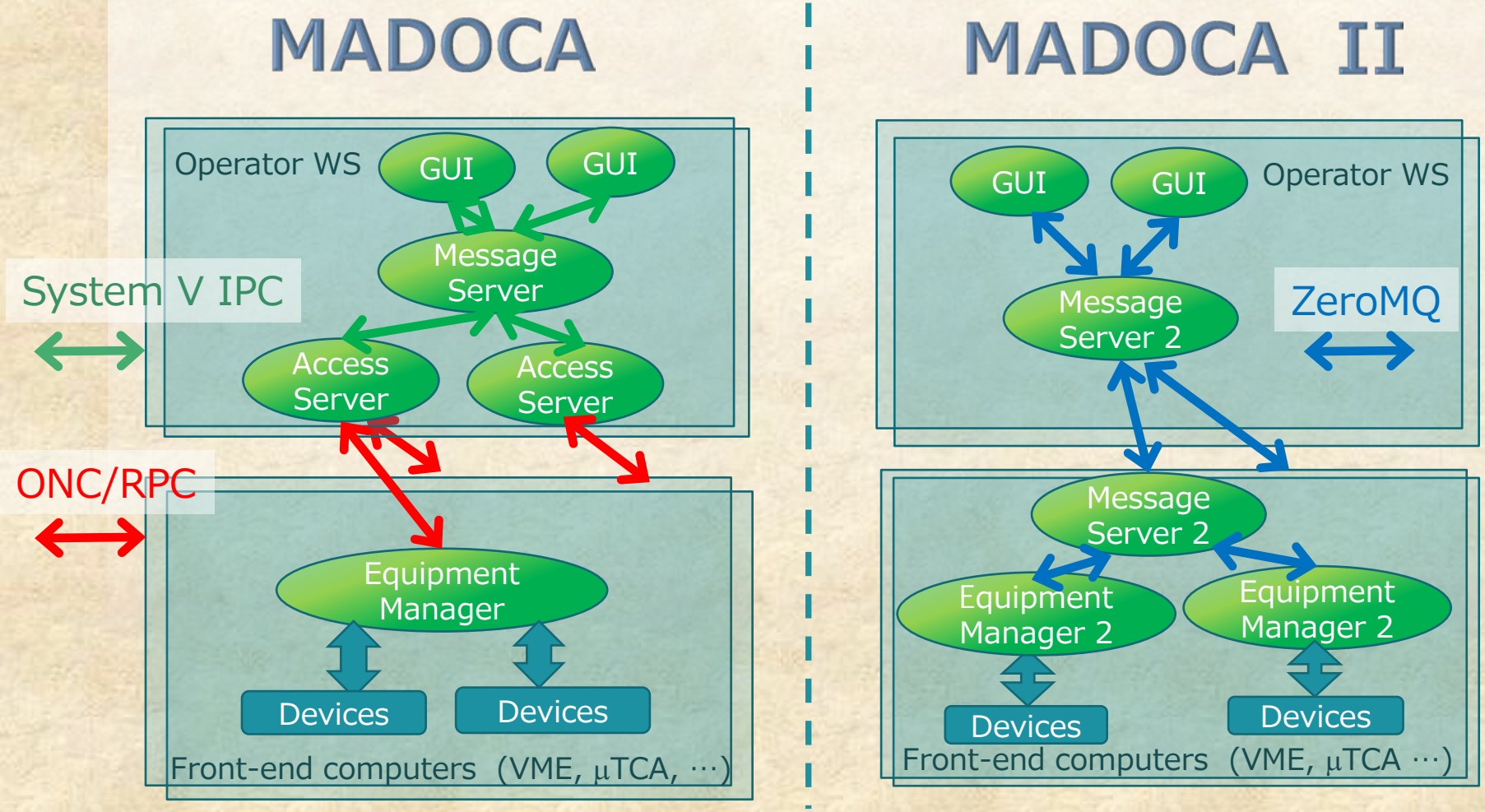
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ZeroMQ @ MADOCA II (1)

✓Messaging with Variable-length data

S/V/O/C

✓Multi-OS

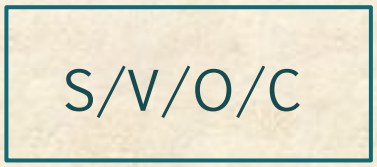
- Can be used for Linux, Solaris

✓Multi-languages

- MADOCA II has been written in C++

ZeroMQ @ MADOCA II (1)

✓Messaging with Variable-length data



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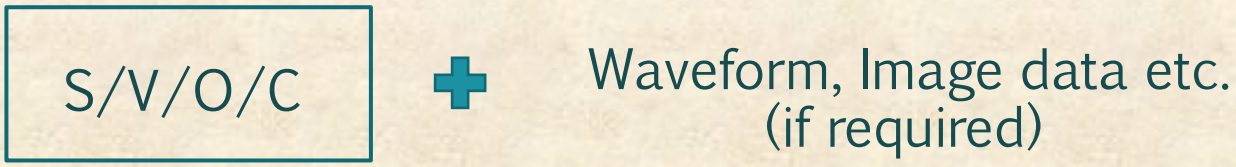

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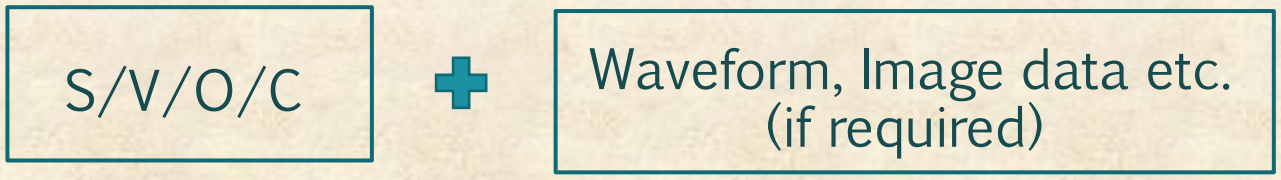

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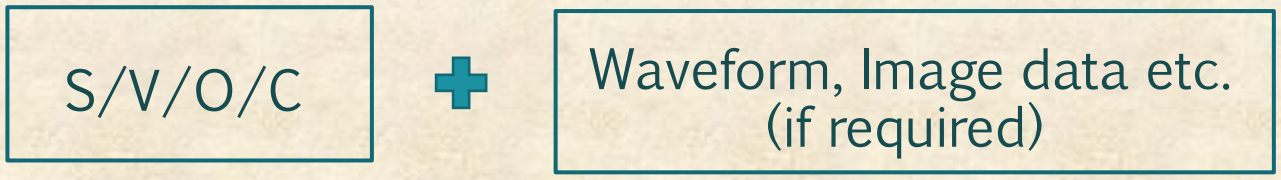

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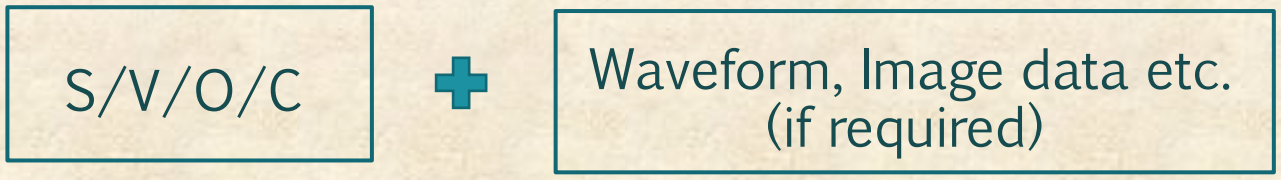


✓Multi-OS

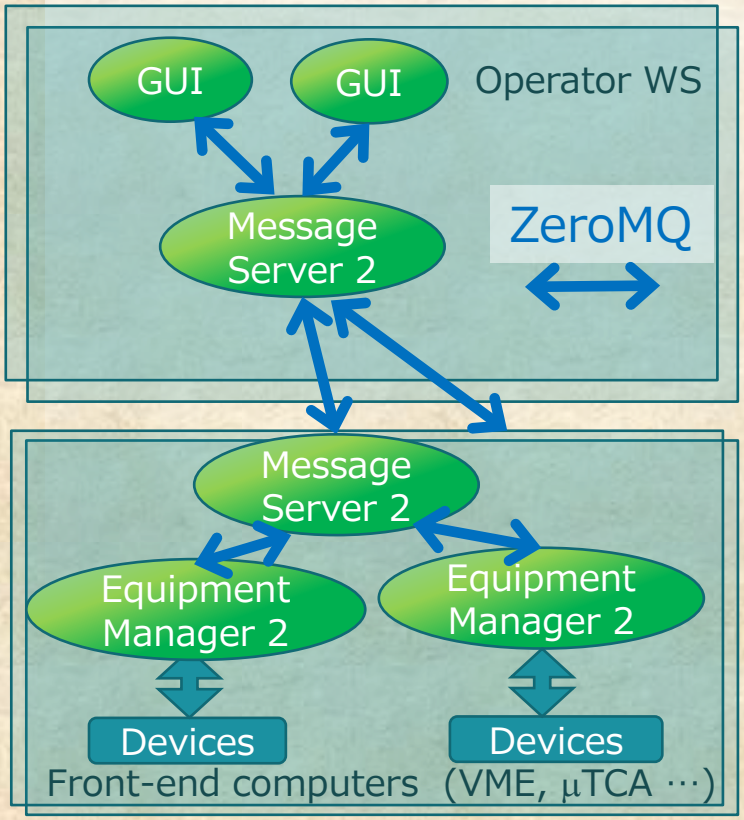
- Can be used for Linux, Solaris and Windows

✓Multi-languages

- MADOCA II has been written in C++

  Also applied to Python and LabVIEW so far

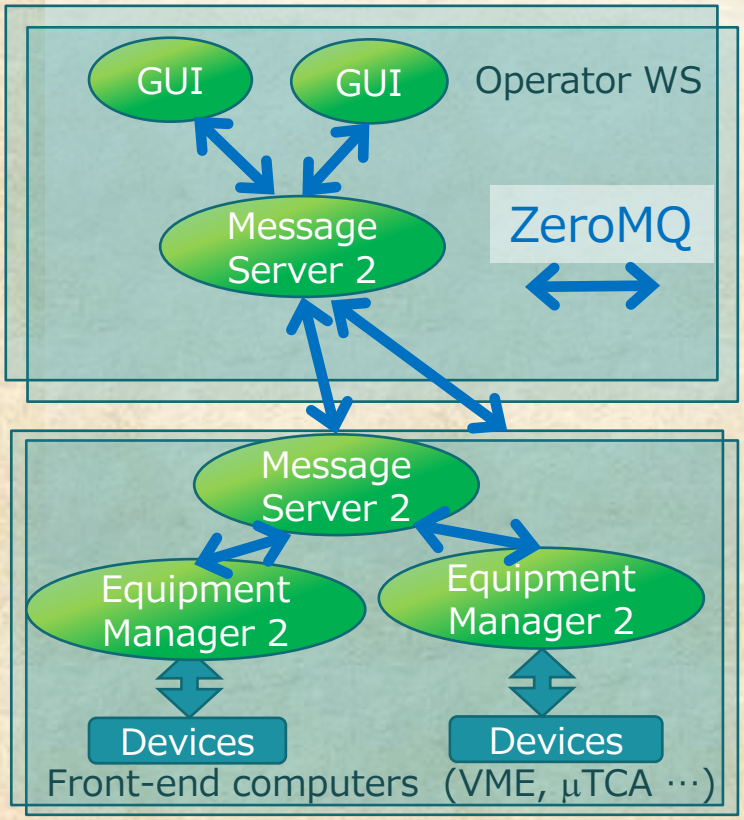
ZeroMQ @ MADOCA II (2)



✓Asynchronous communications

- No need to wait to finish processing of each message

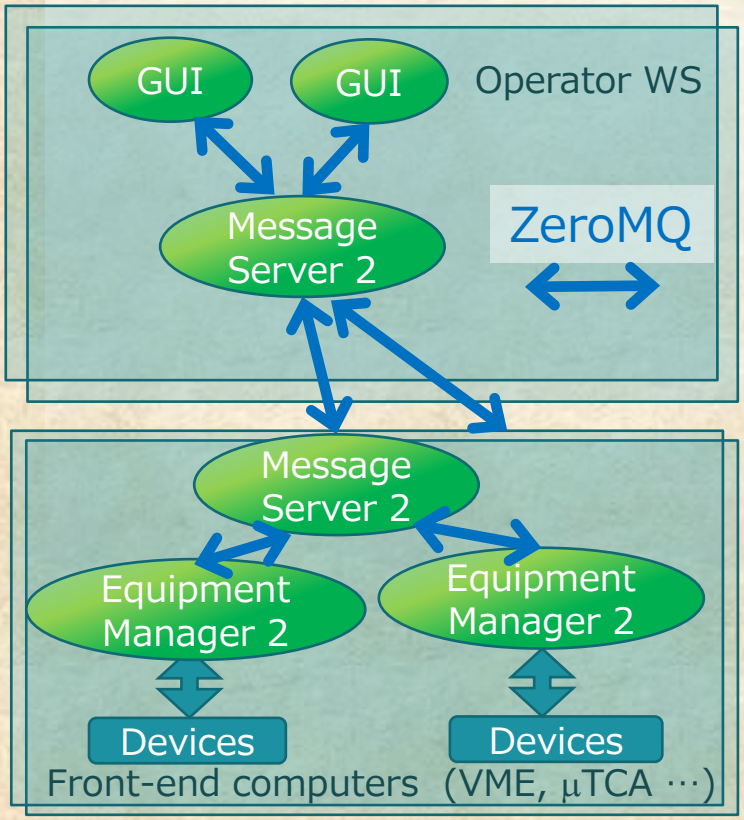
ZeroMQ @ MADOCA II (2)



✓Asynchronous communications

- No need to wait to finish processing of each message
  - Message ID is assigned to each message to handle the relation between sending and reception

ZeroMQ @ MADOCA II (2)



✓Asynchronous communications

- No need to wait to finish processing of each message
  - Message ID is assigned to each message to handle the relation between sending and reception
- Distributed processing of control messages
  - Multiple Equipment Managers can help

MessagePack @MADOCA II (1)

Used for Serialization of Messaging data

✓Message exchange among different computing environments

- byte-order procedures are managed

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✓Flexible data formats

→ Applied to variable-length data, No size limit

MessagePack @MADOCA II (1)

Used for Serialization of Messaging data

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Array

MessagePack @MADOCA II (1)

Used for Serialization of Messaging data

✓Message exchange among different computing environments

- byte-order procedures are managed

✓Flexible data formats

→ Applied to variable-length data, No size limit

Array [1.23, 4.56,7.89, ⋯]

MessagePack @MADOCA II (1)

Used for Serialization of Messaging data

✓Message exchange among different computing environments

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Array [1.23, 4.56,7.89, ⋯]

Map

MessagePack @MADOCA II (1)

Used for Serialization of Messaging data

✓Message exchange among different computing environments

- byte-order procedures are managed

✓Flexible data formats

→ Applied to variable-length data, No size limit

Array [1.23, 4.56,7.89, …]

Map { “image_data_type” : “MONO”,
“image_data”: [1,3,5,…] }

MessagePack @MADOCA II (1)

Used for Serialization of Messaging data

✓Message exchange among different computing environments

- byte-order procedures are managed

✓Flexible data formats

→ Applied to variable-length data, No size limit

Array [1.23, 4.56,7.89, ⋯]

Map { “image_data_type” : “MONO”, “image_data”: [1,3,5,⋯] }

→ Waveform

MessagePack @MADOCA II (1)

Used for Serialization of Messaging data

✓Message exchange among different computing environments

- byte-order procedures are managed

✓Flexible data formats

→ Applied to variable-length data, No size limit

Array [1.23, 4.56,7.89, ⋯] → Waveform

Map { “image_data_type” : “MONO”, “image_data”: [1,3,5,⋯] } → Image

MessagePack @MADOCA II (2)

Case for Image:

Key	Data format	Value
image_data_type	string	“MONO”, ”RGB”, ”RGBA”
image_width	int32_t	
image_height	int32_t	
image_depth	int32_t	
image_num_type	string	“int32_t”,”uint16_t,” “uint32_t”,”uint64_t,” “int16_t”, “int32_t”,”int64_t”,”float”,”double”
image_data	defined by [image_num_type]	→Array
image_pixel_order	string	“lefttop”, “leftbottom”

MessagePack @MADOCA II (2)

Case for Image:

Key	Data format	Value
image_data_type	string	“MONO”, ”RGB”, ”RGBA”
image_width	int32_t	
image_height	int32_t	
image_depth	int32_t	
image_num_type	string	“int32_t”,”uint16_t,” “uint32_t”,”uint64_t,” “int16_t”, “int32_t”,”int64_t”,”float”,”double”
image_data	defined by [image_num_type]	→Array
image_pixel_order	string	“lefttop”, “leftbottom”

Key’s can be flexibly added by users

MADOCA II Performance (1)

Operator WS

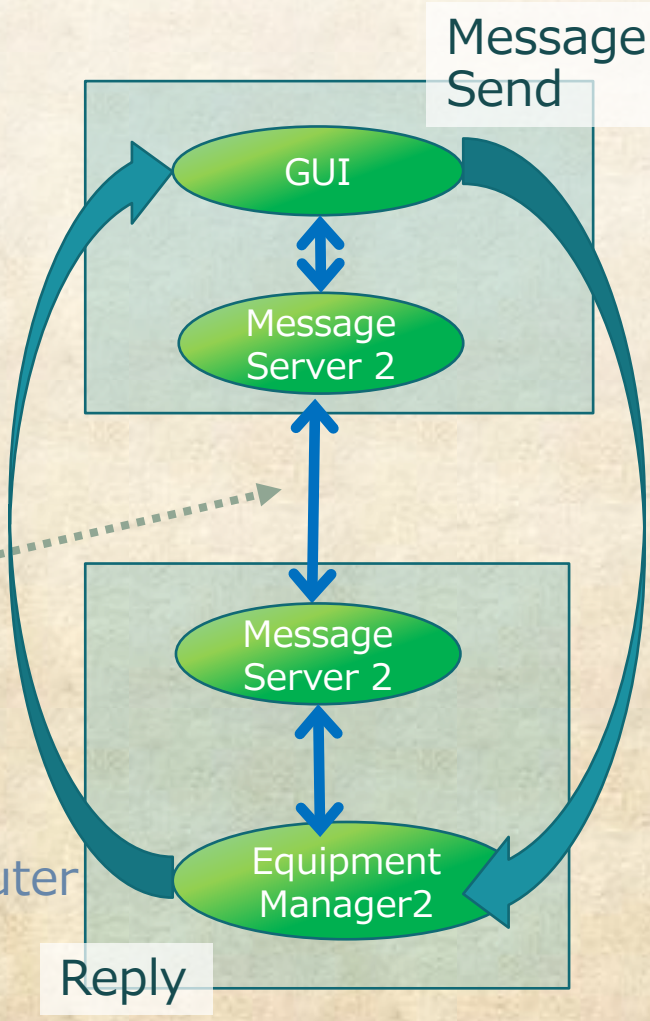
Core i7-2670QM
2.2GHz

Network

GbE cable
* Direct connection

Front-end computer

Core 2Duo P9500
2.53GHz

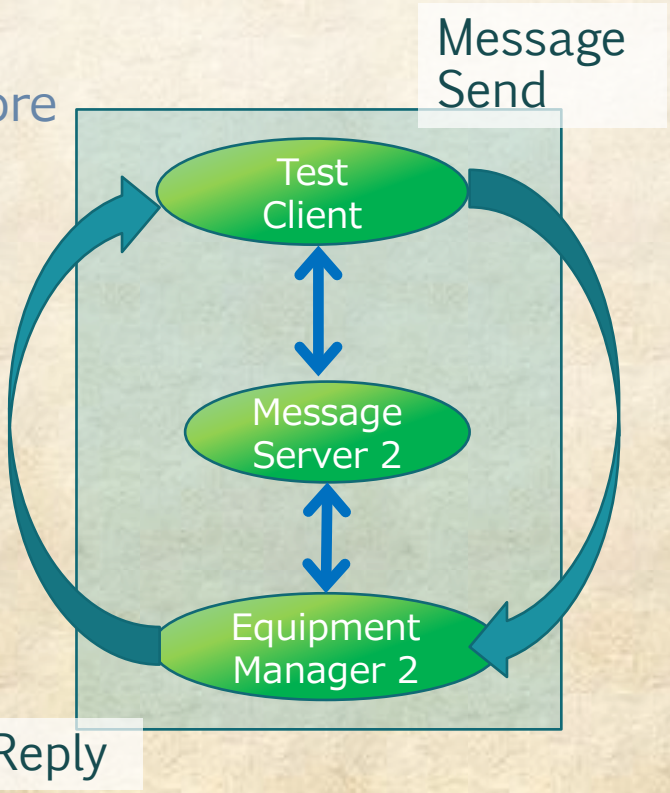


Message size
80 byte

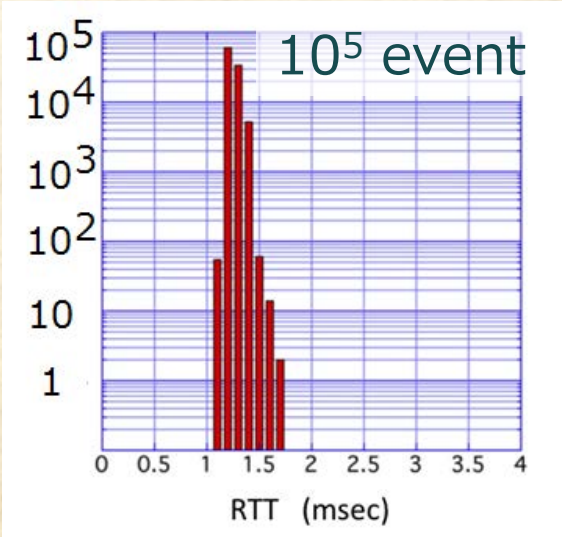
- Round Trip Time (RTT)
  - 1.2 msec / message
  - > 850 Hz

MADOCA II Performance (2)

Solaris
Multi-core
CPU



- "Real-time Process control on Multi-core Processors"
  - MOPPC128 M. Ishii et al.

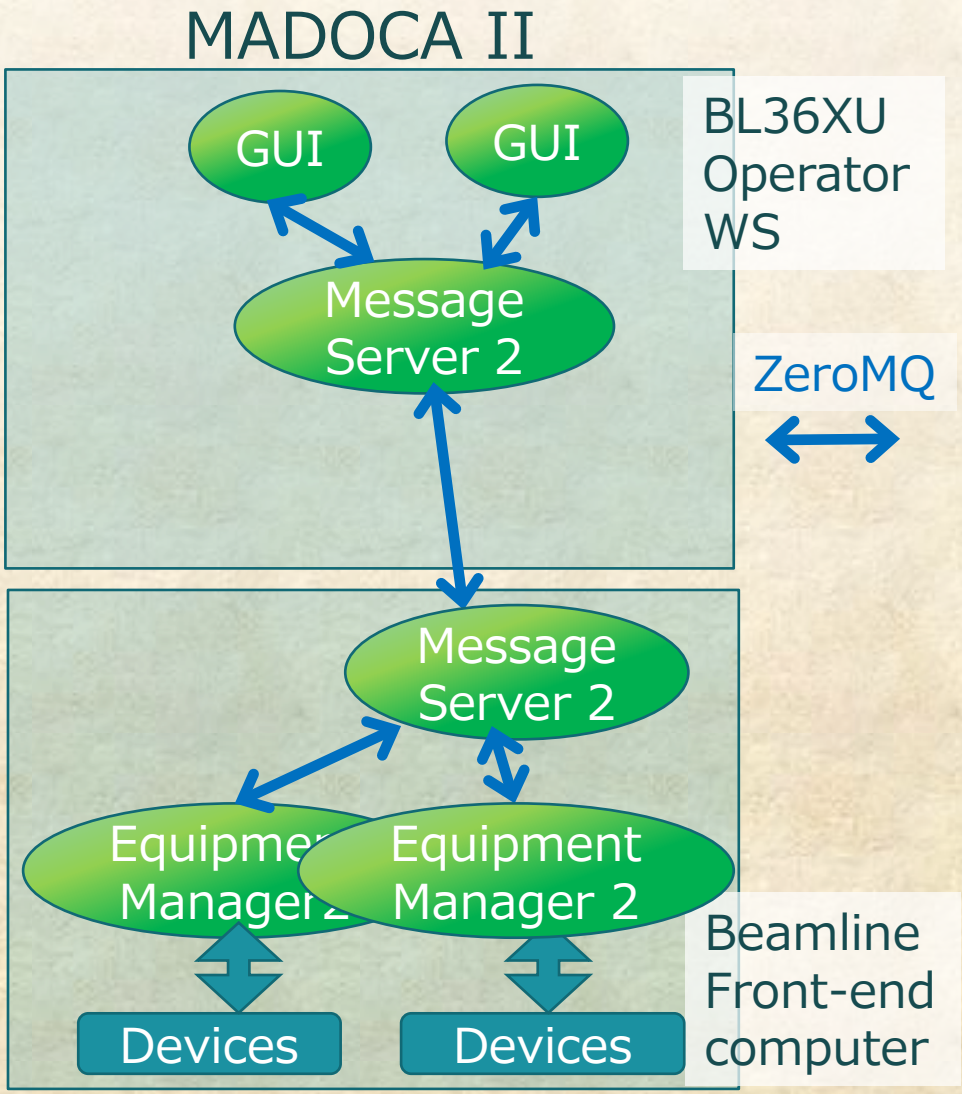


- RTT < 2ms
  - With binding processes into real-time class

→ Real-time control

MADOCA II @ BL36XU beamline

Since Sep. 2012



MADOCA II @ BL36XU beamline

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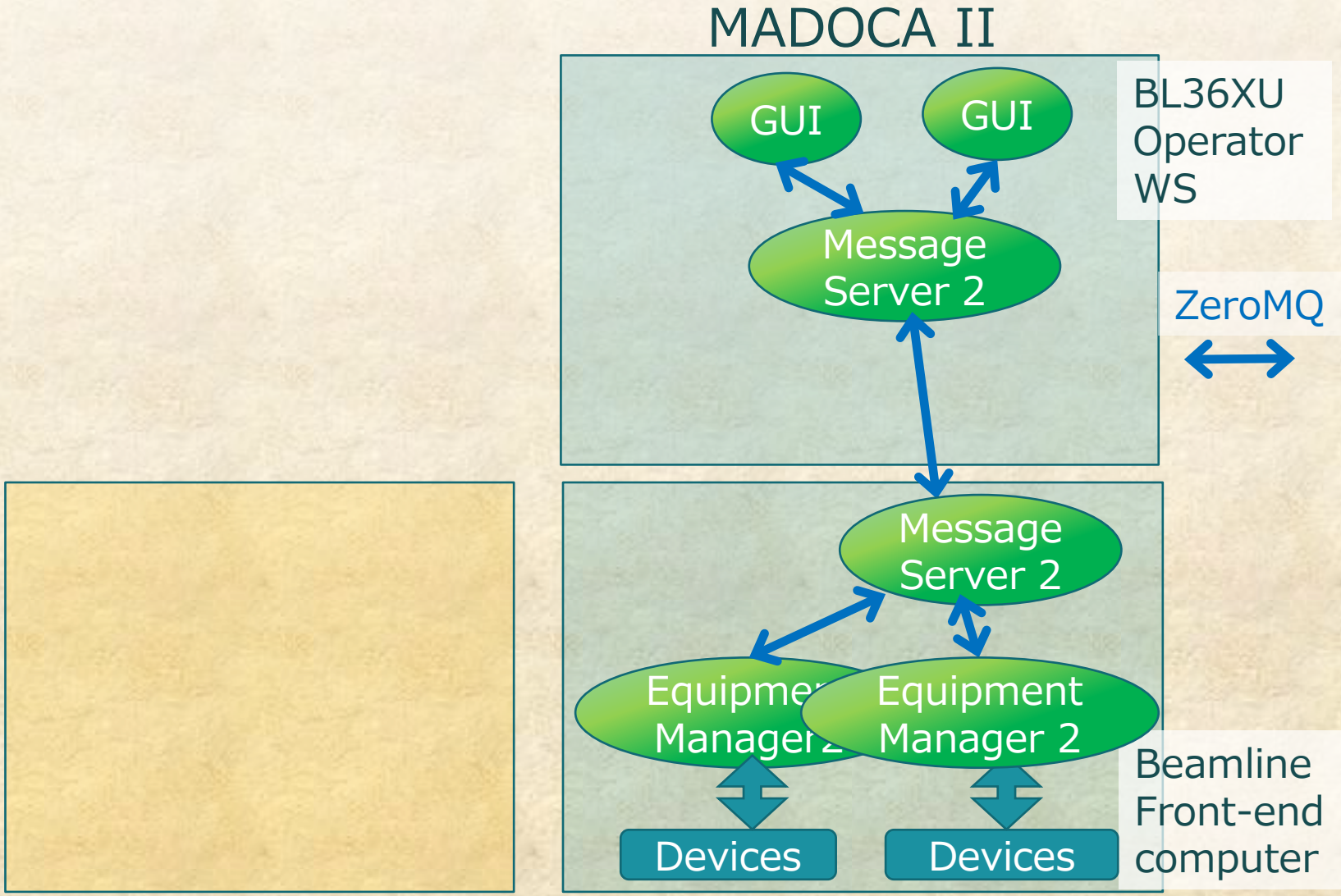

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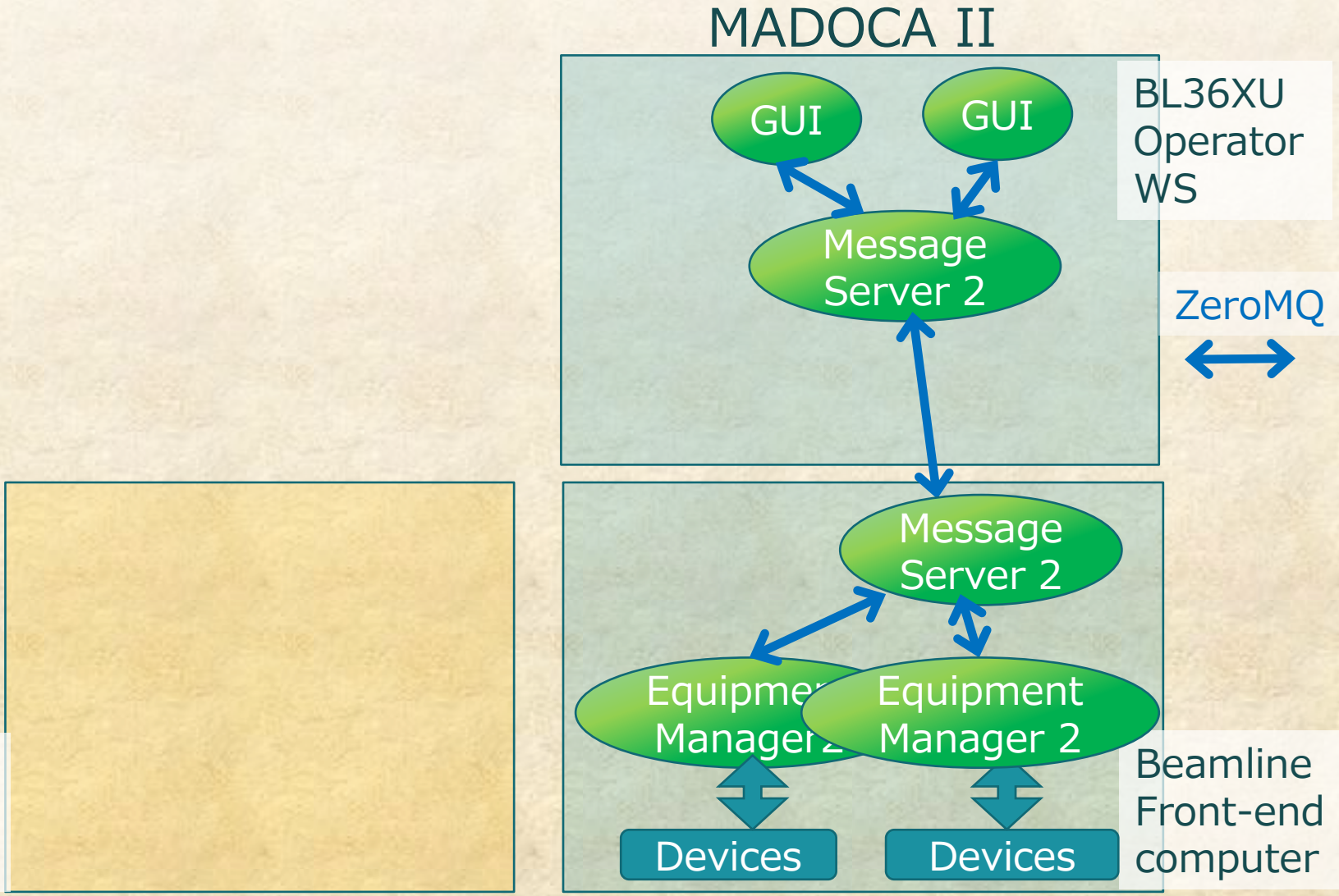

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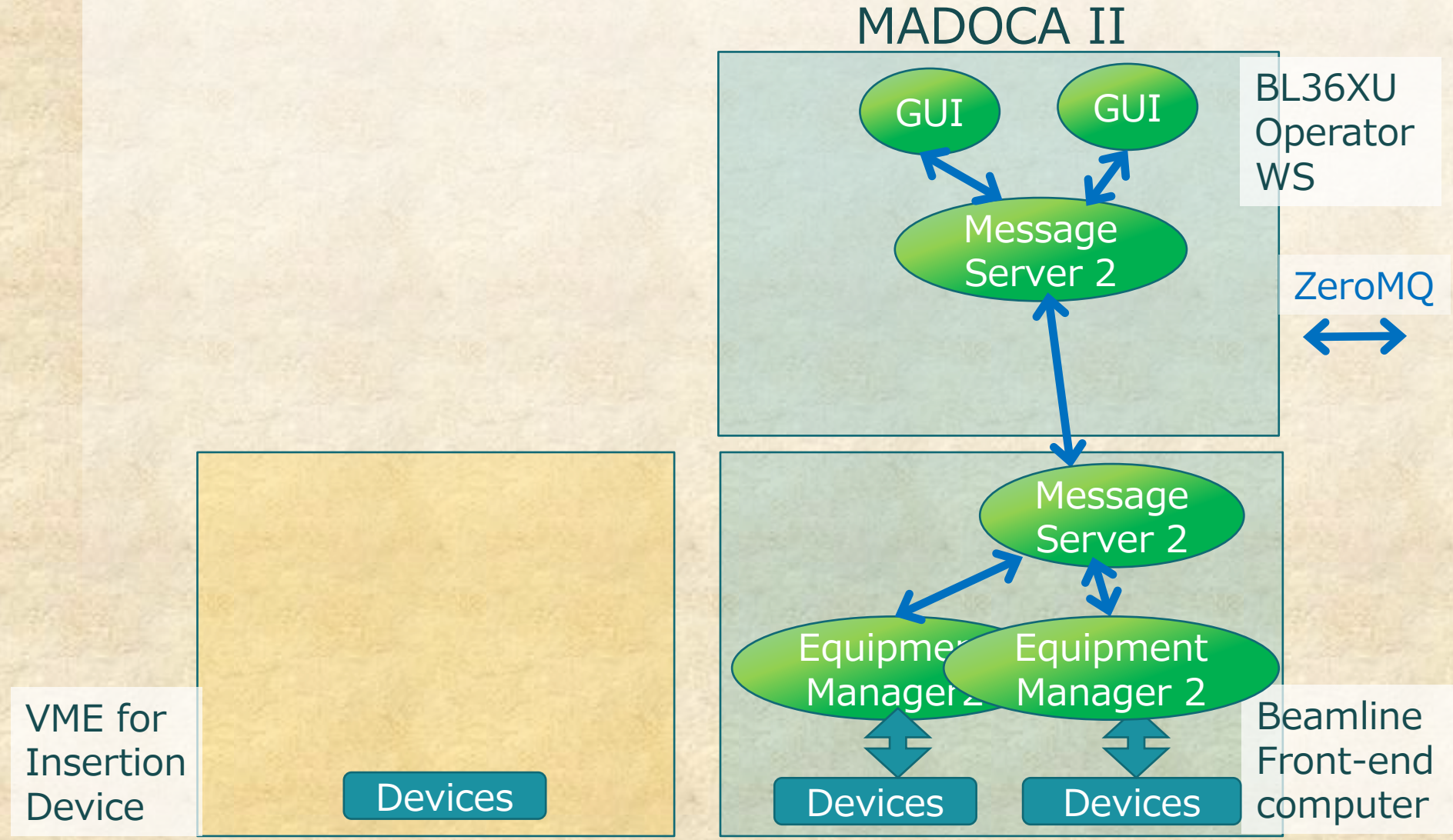

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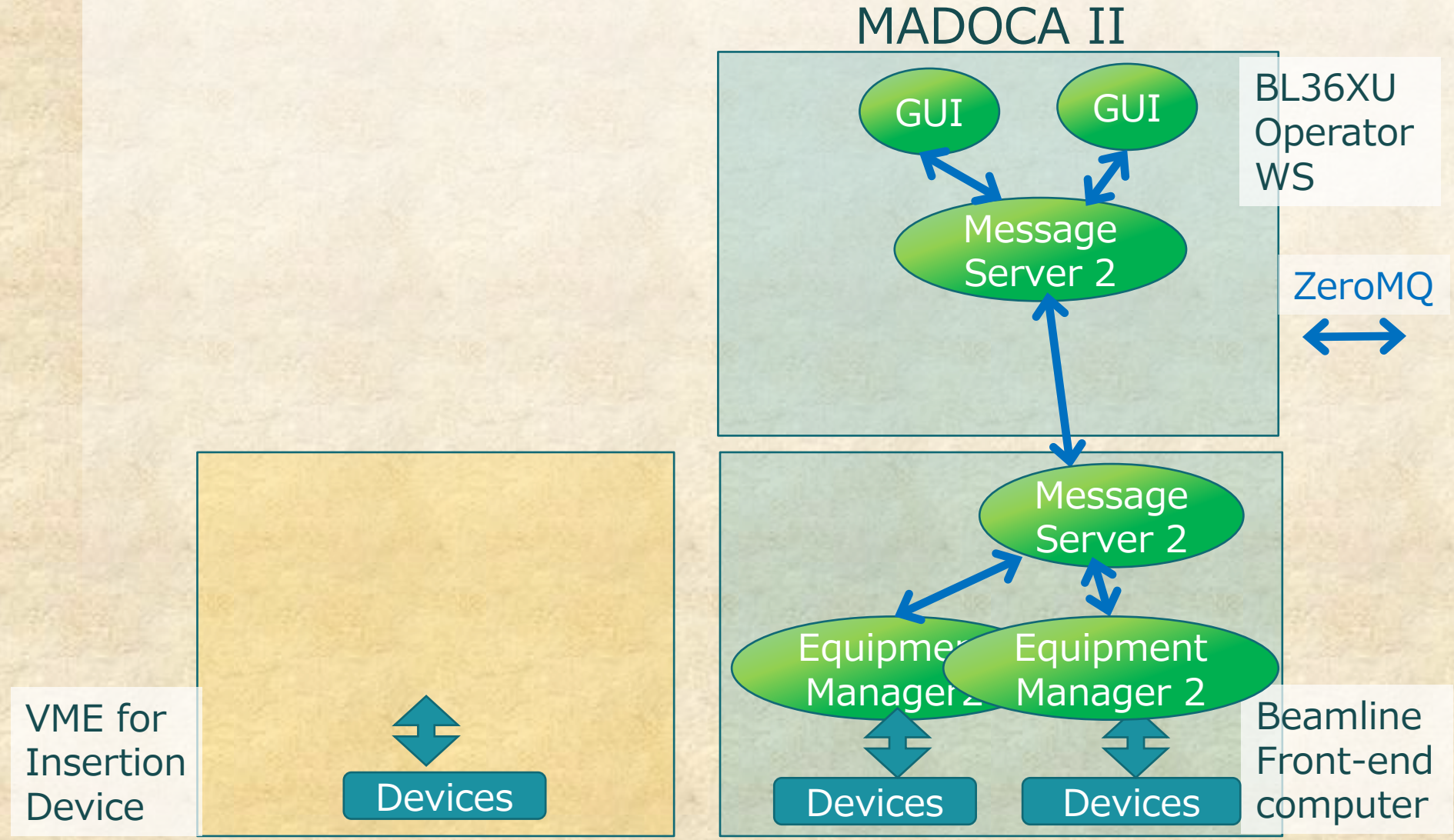

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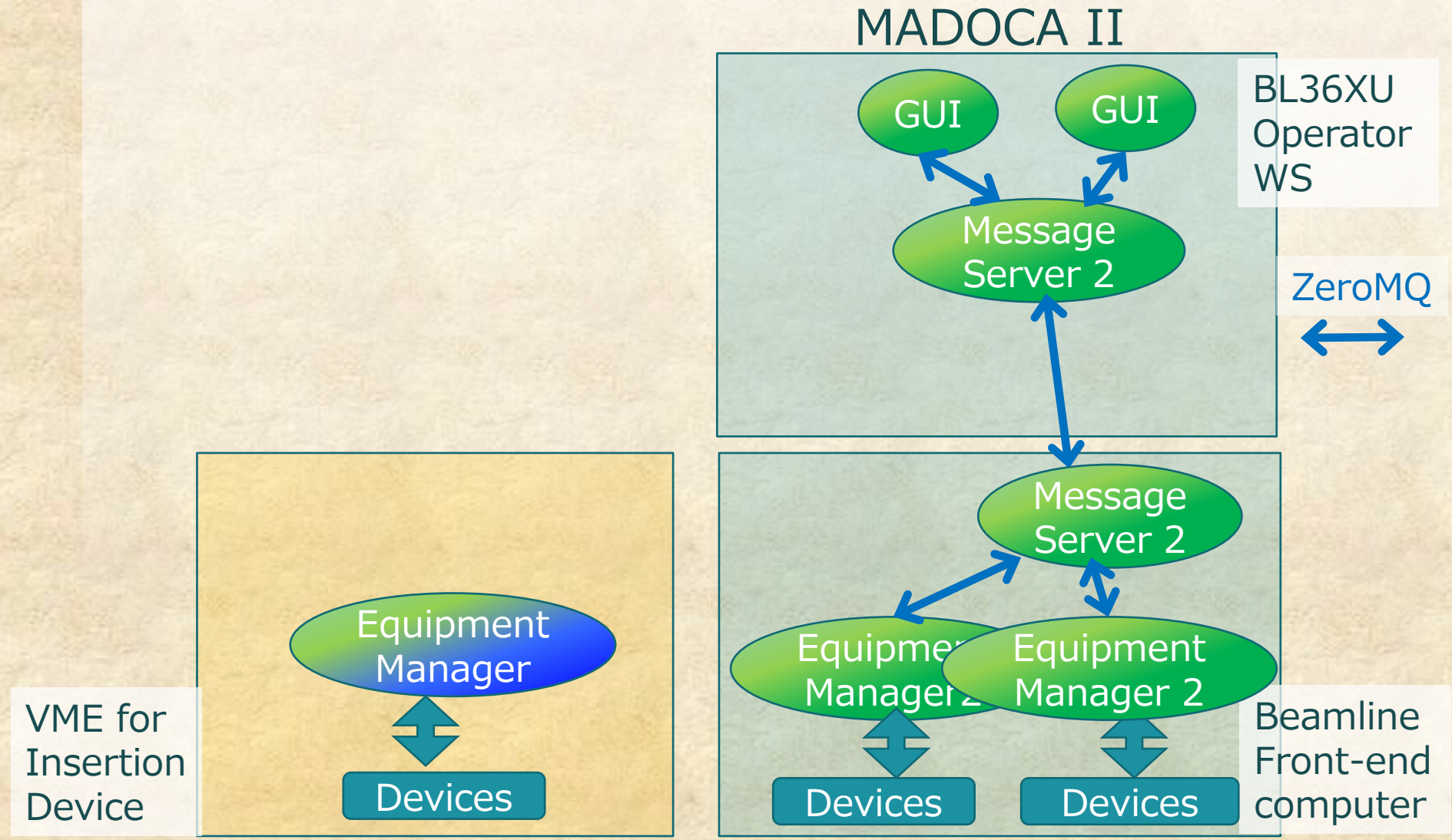

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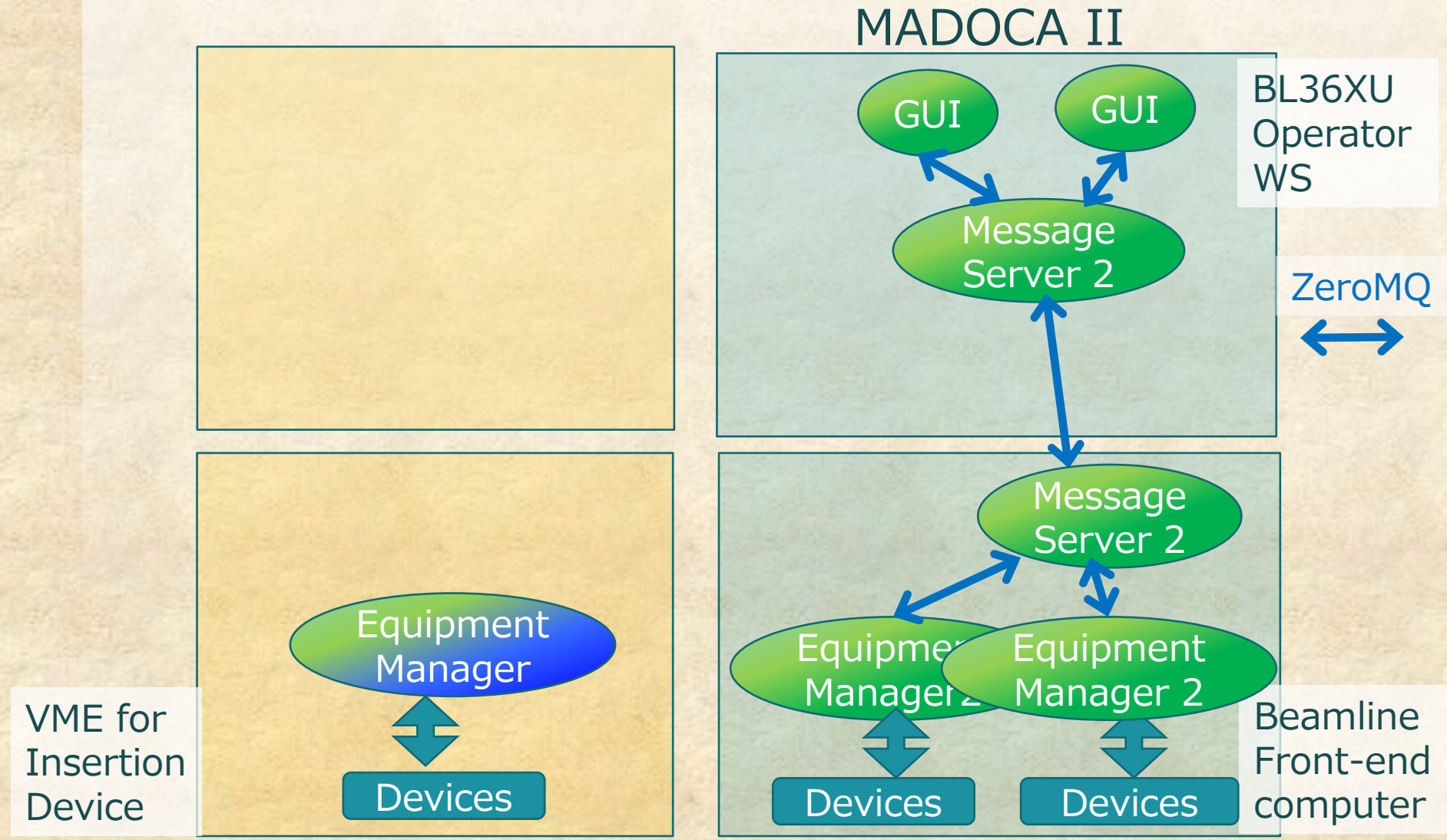

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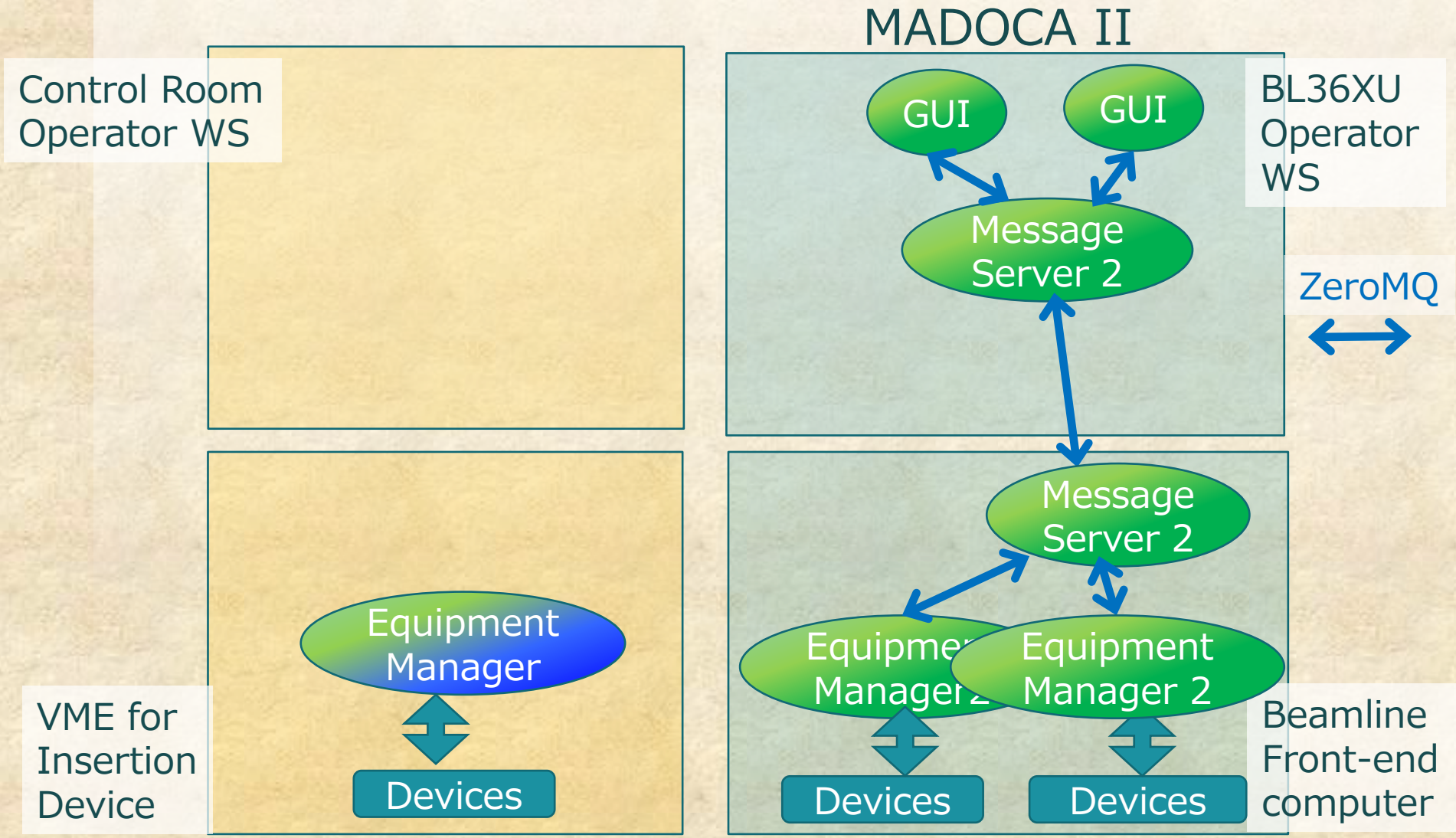

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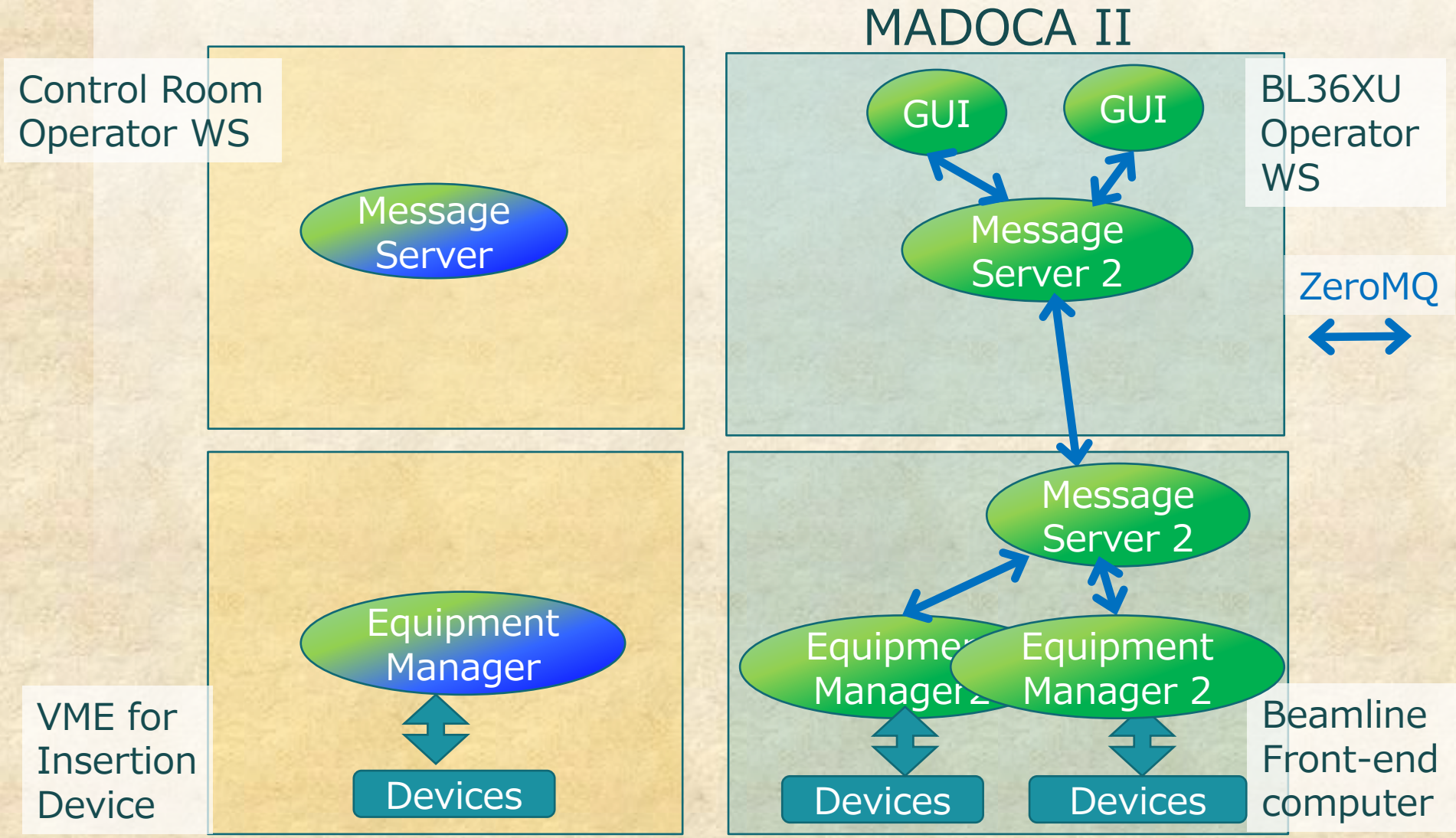

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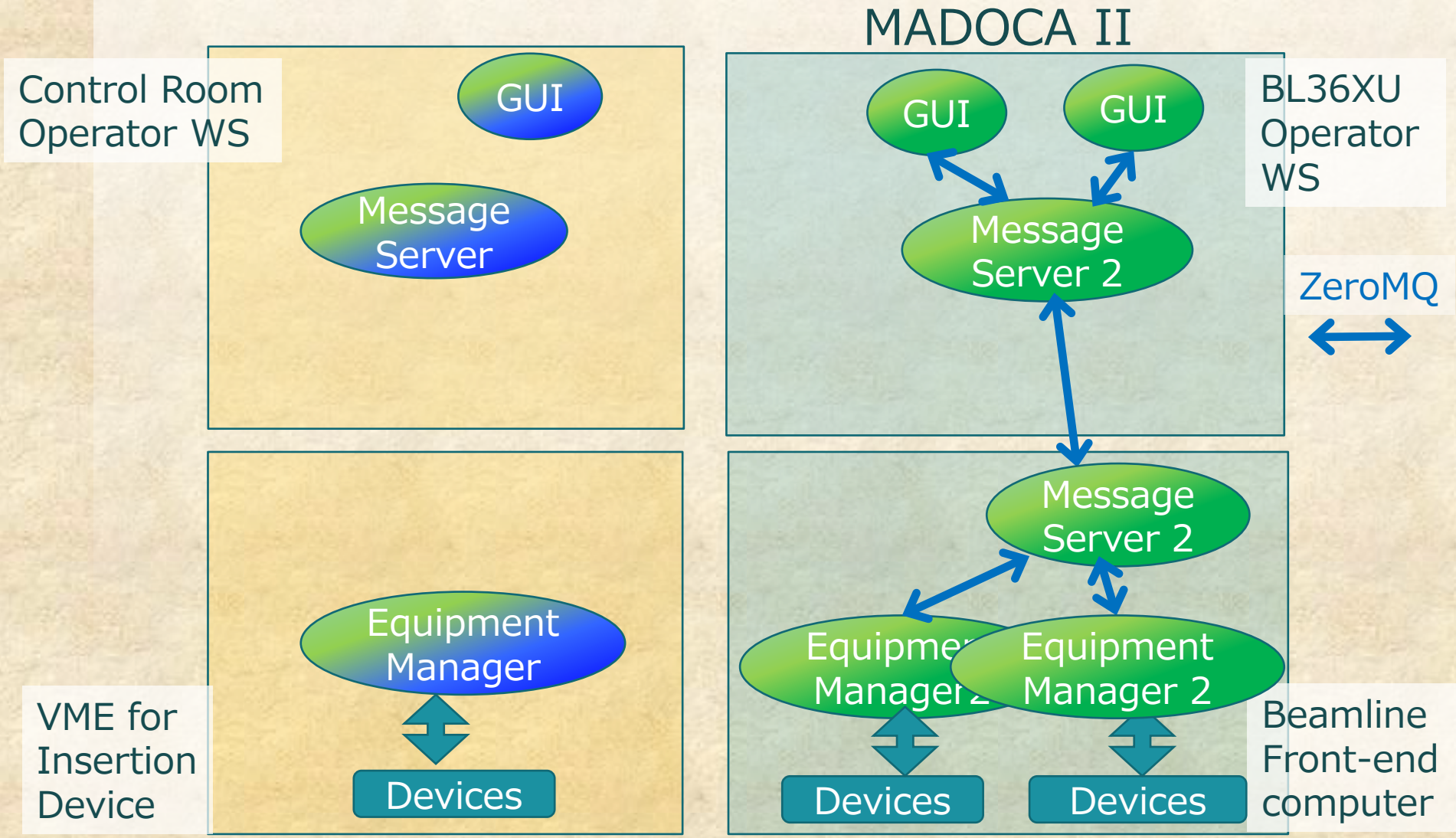

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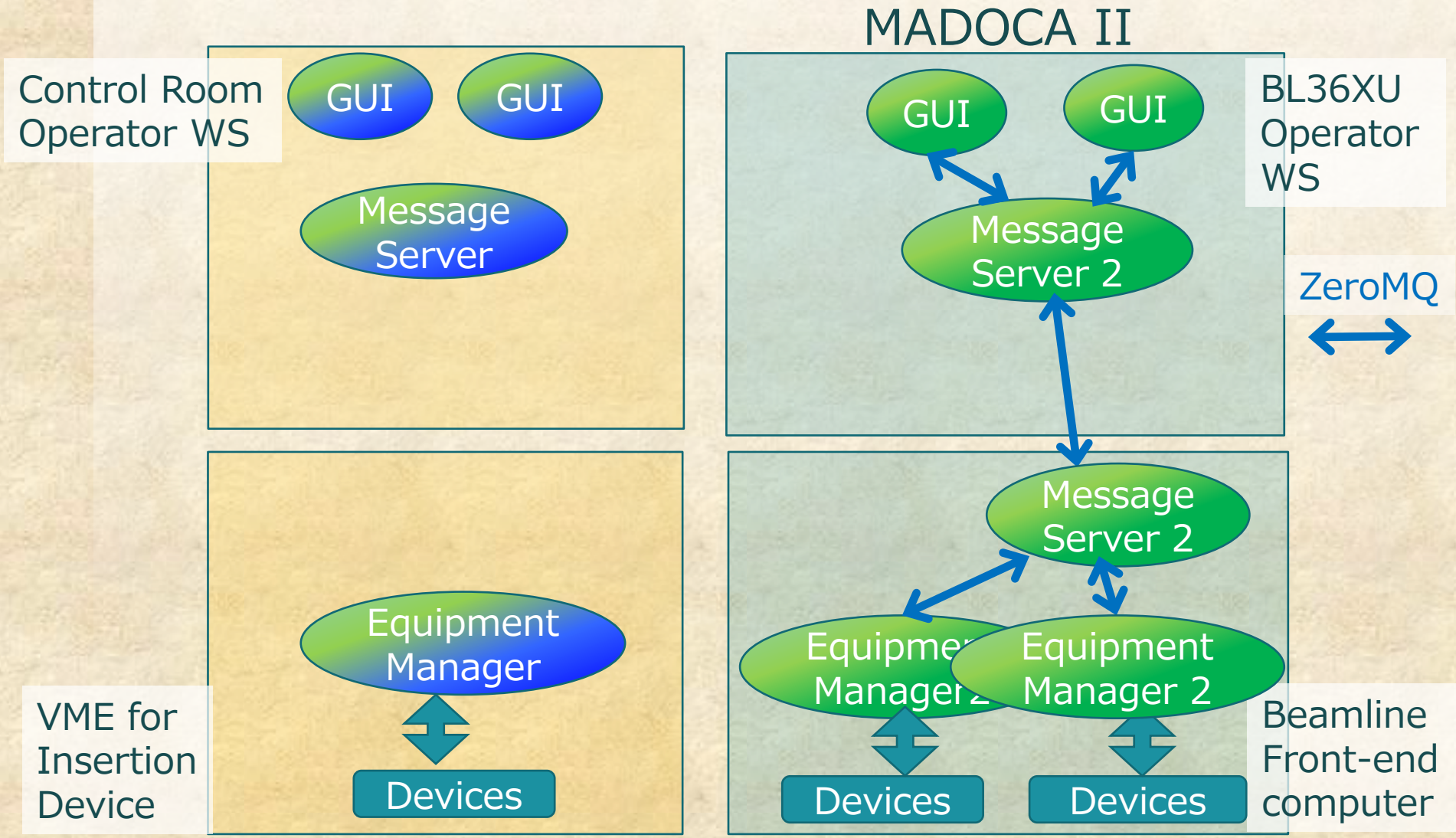

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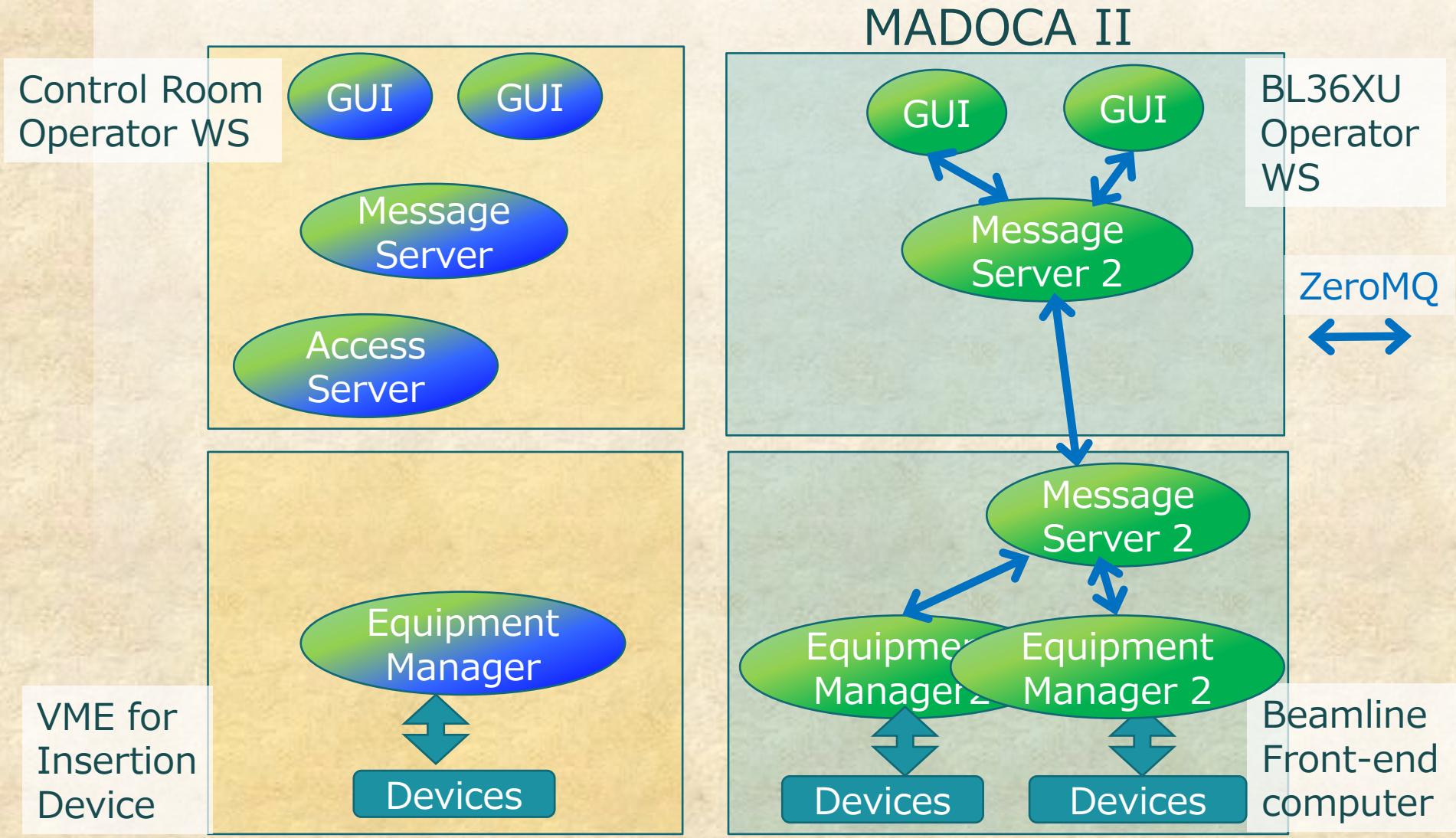

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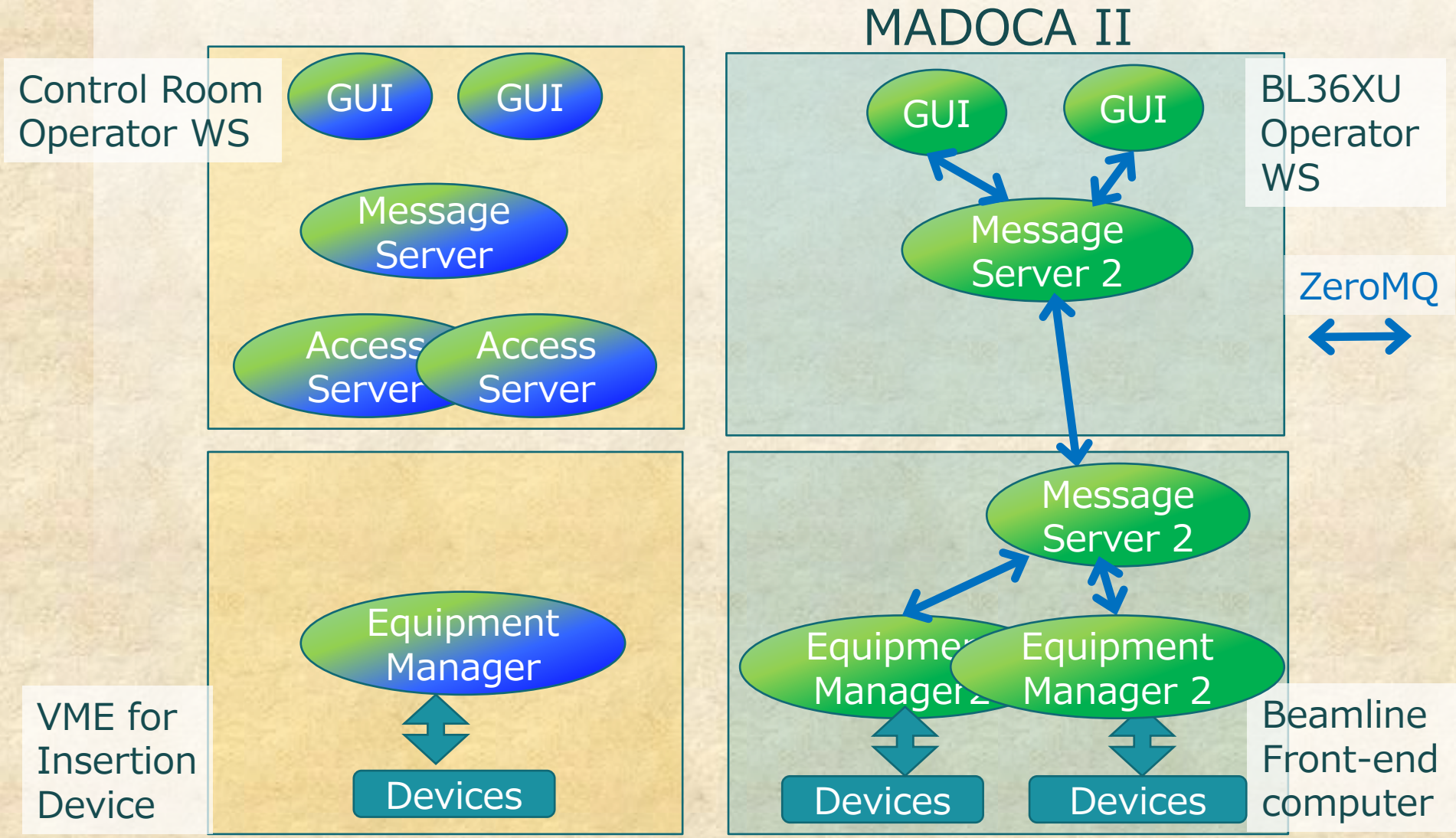

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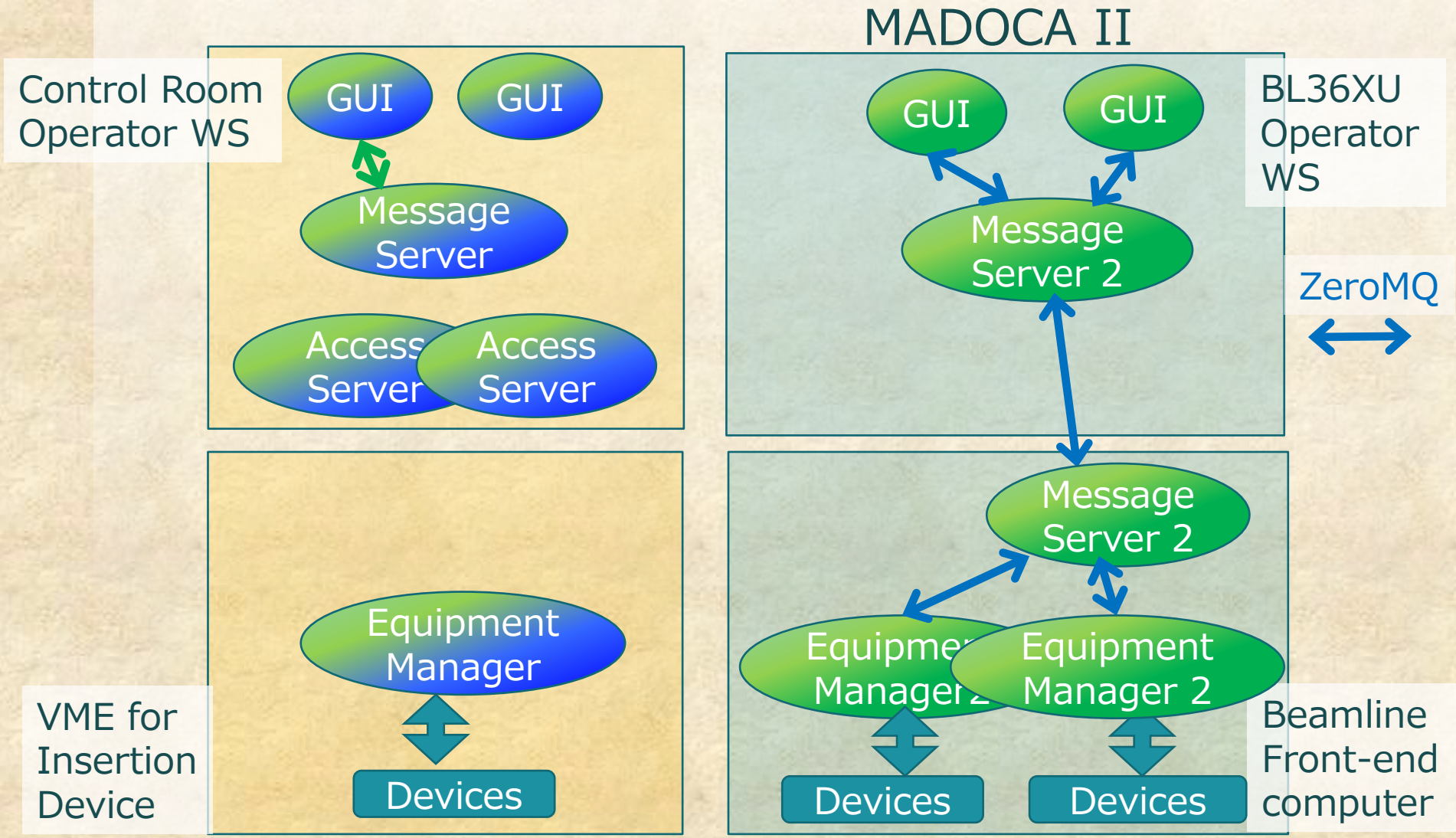

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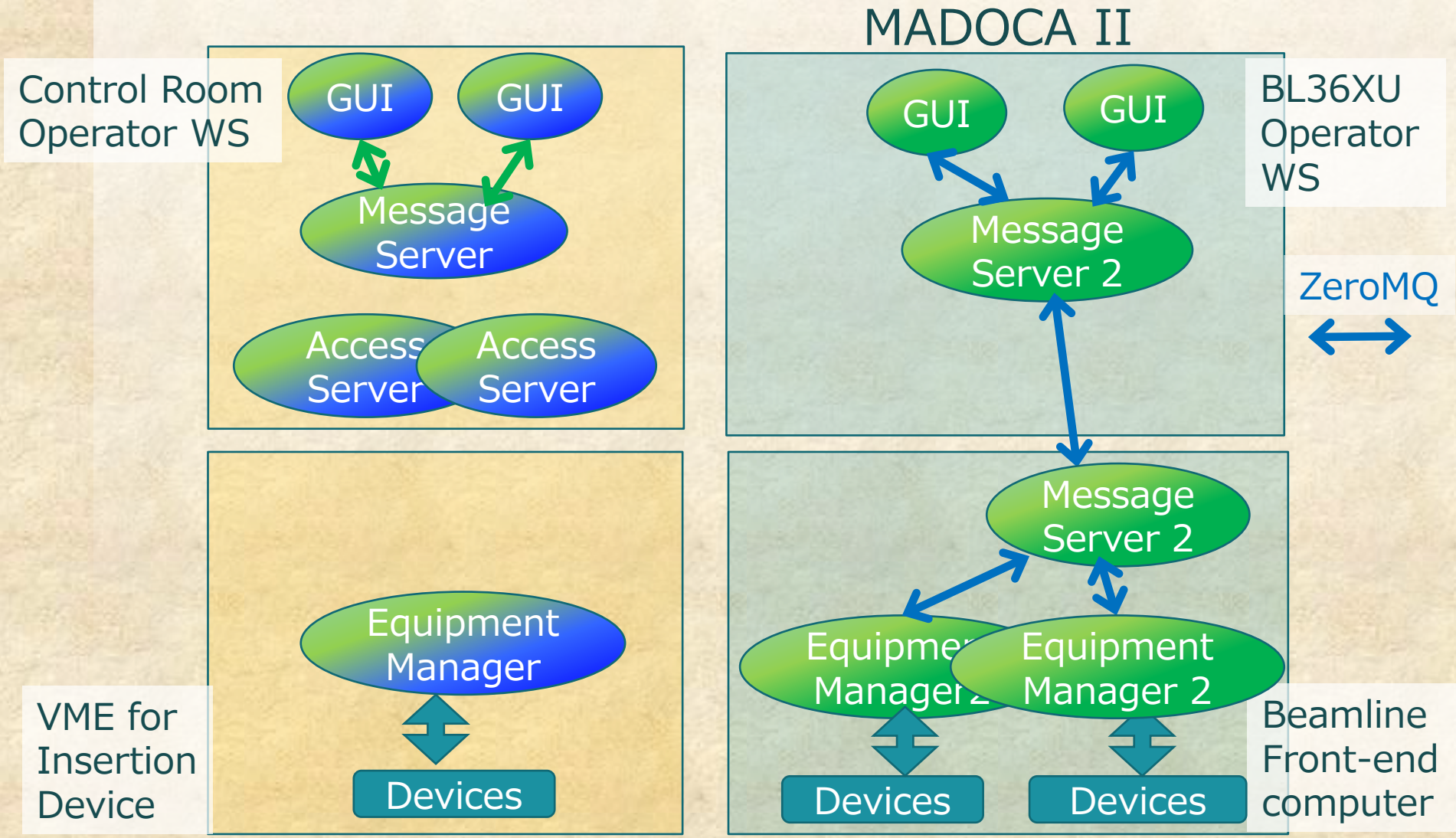

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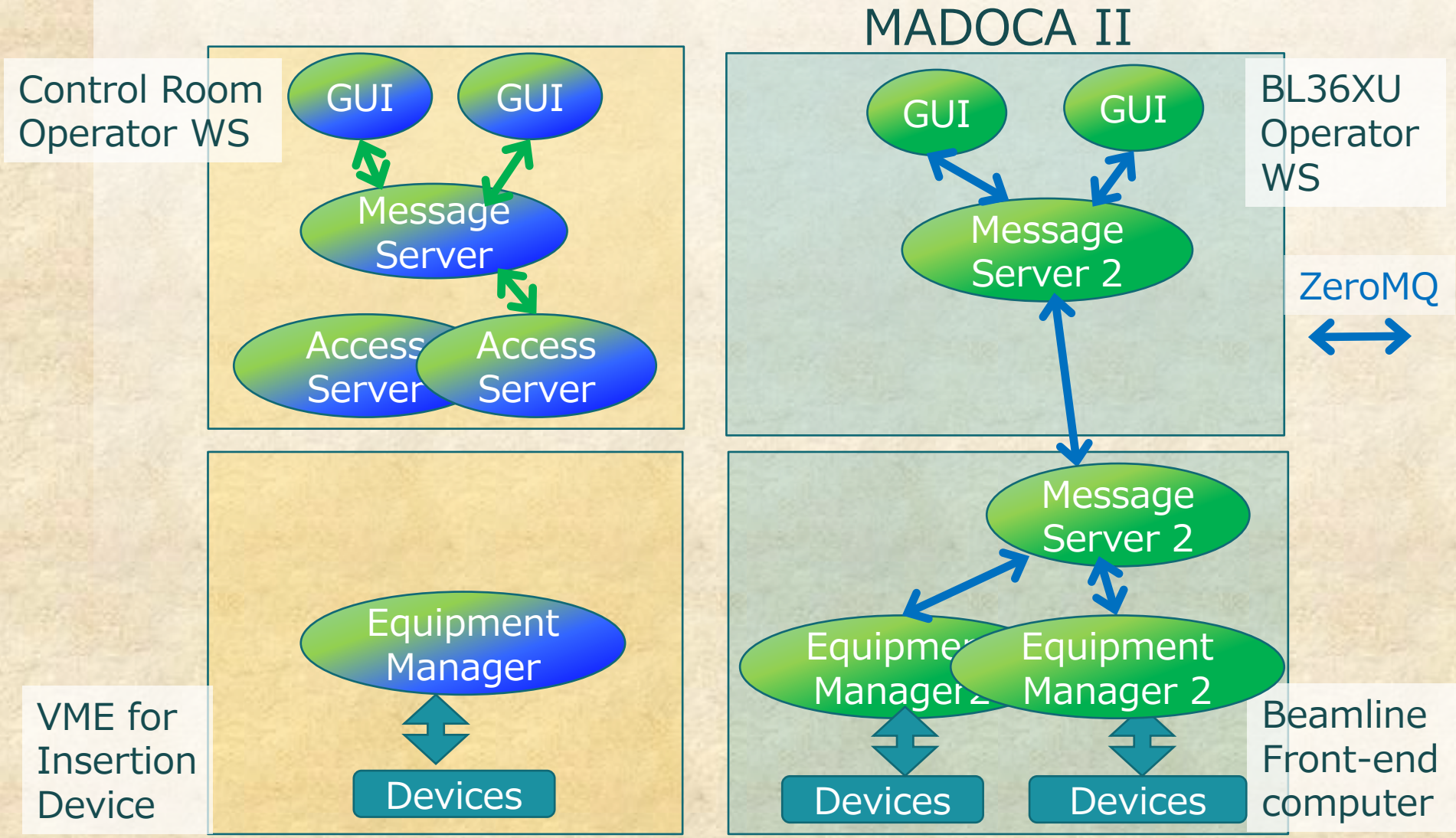

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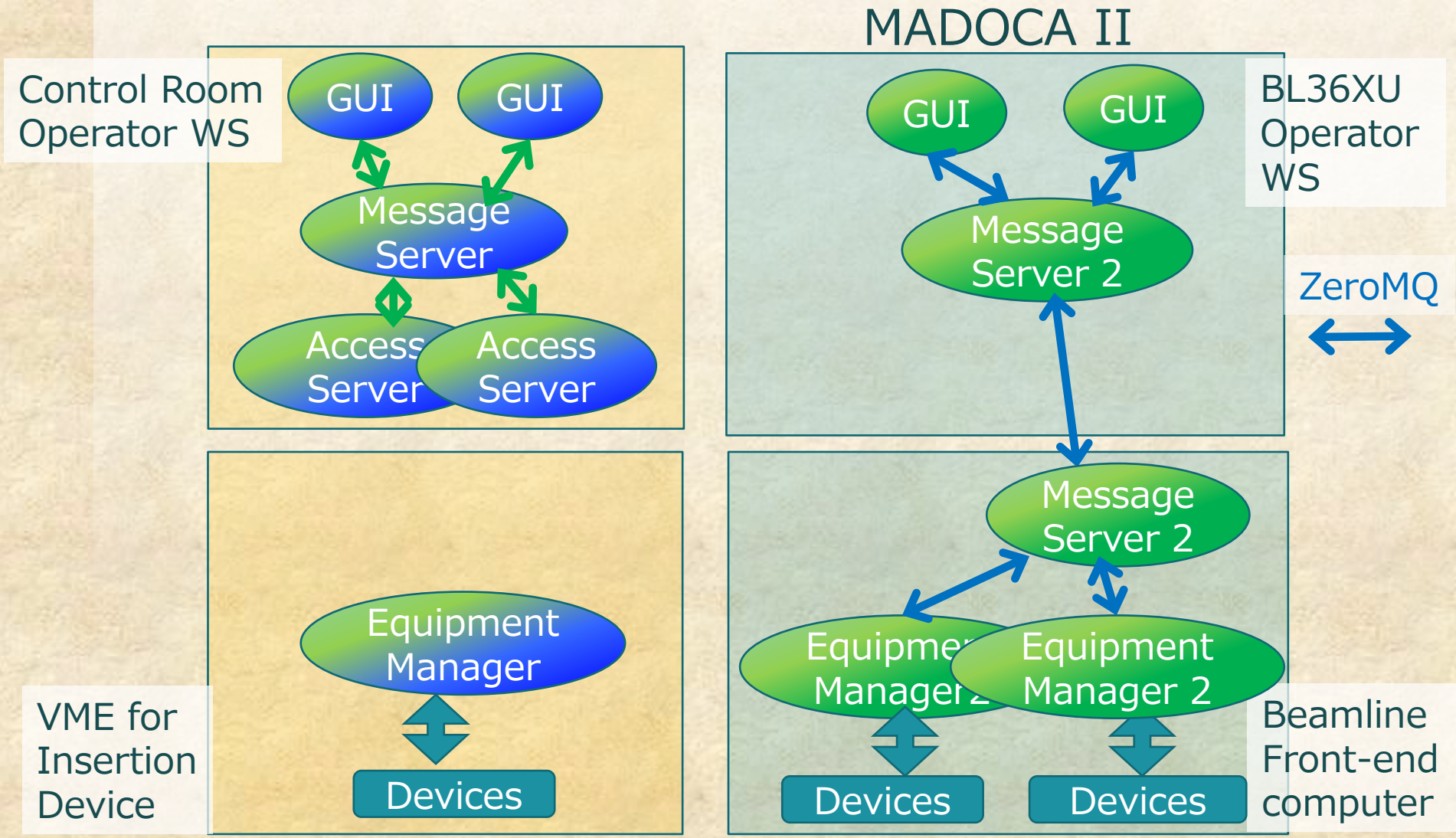

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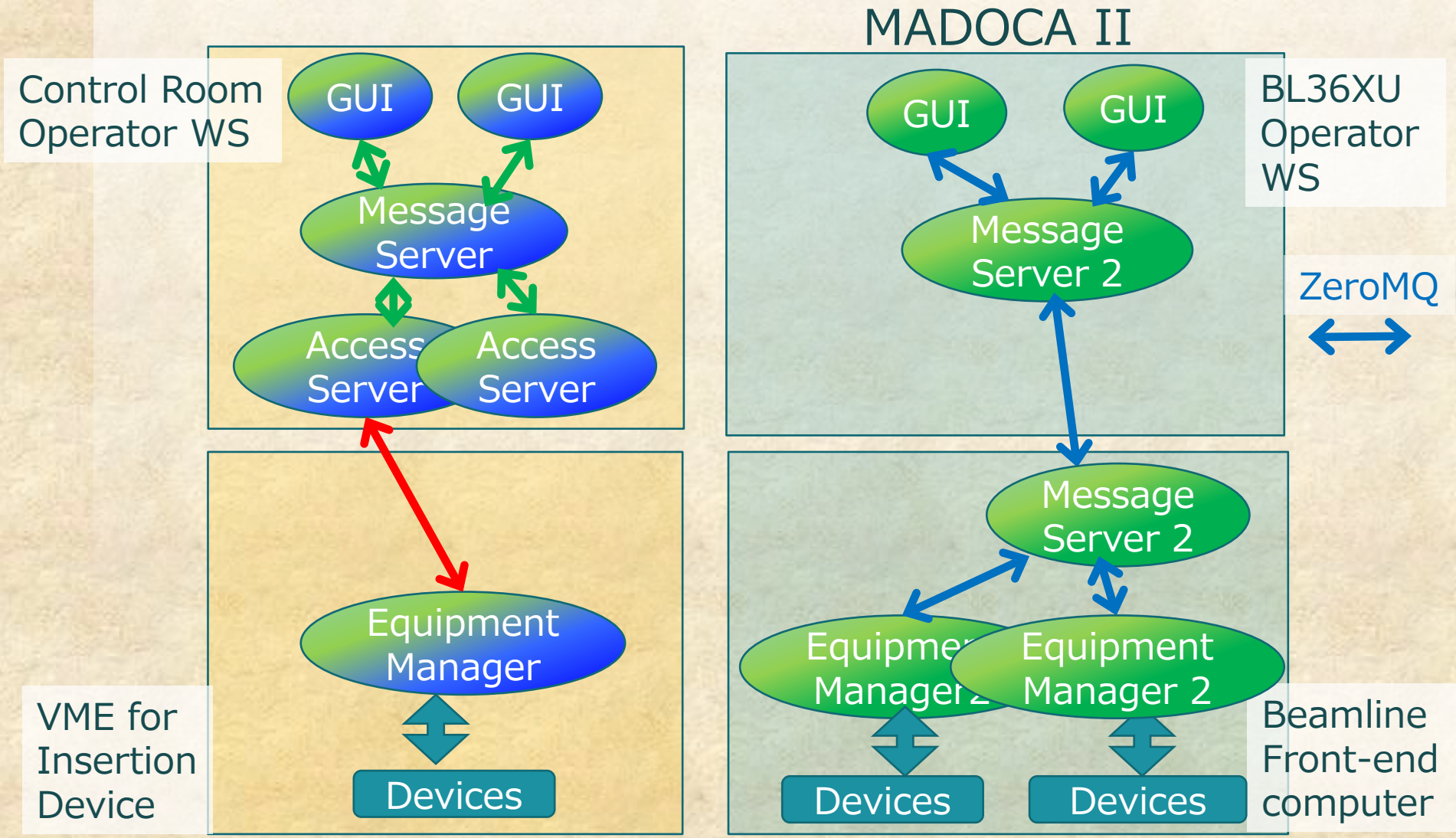

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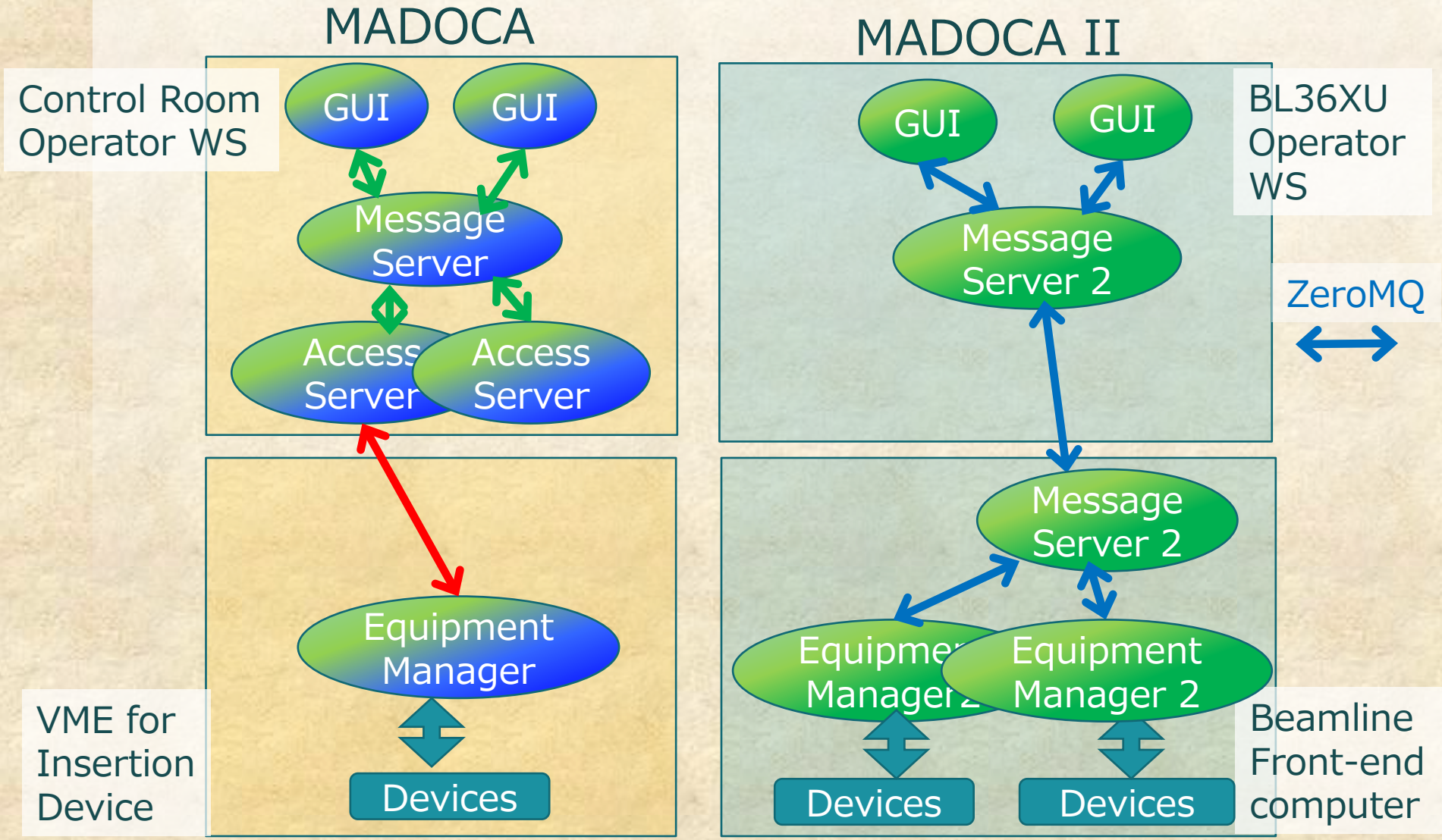

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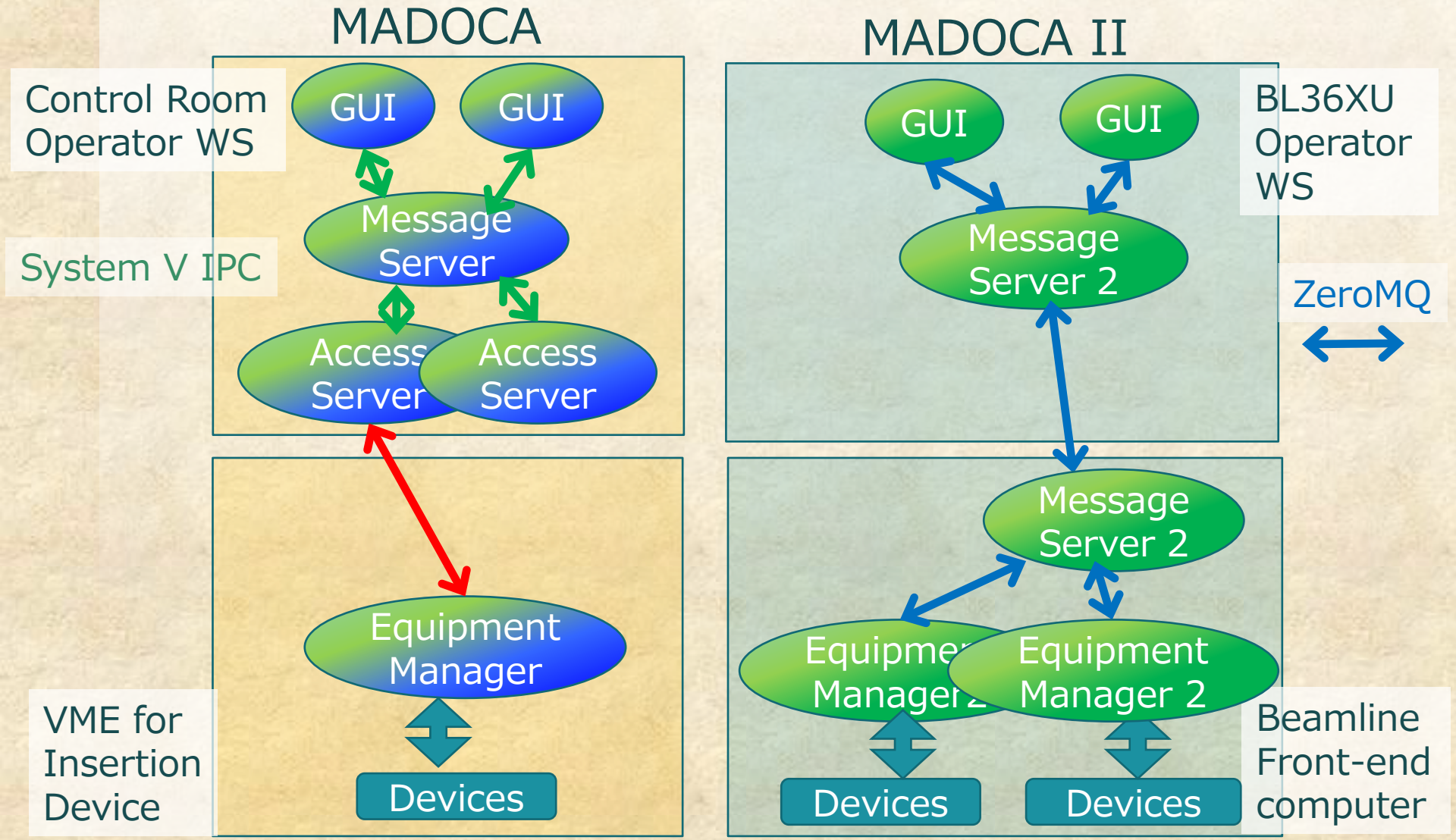

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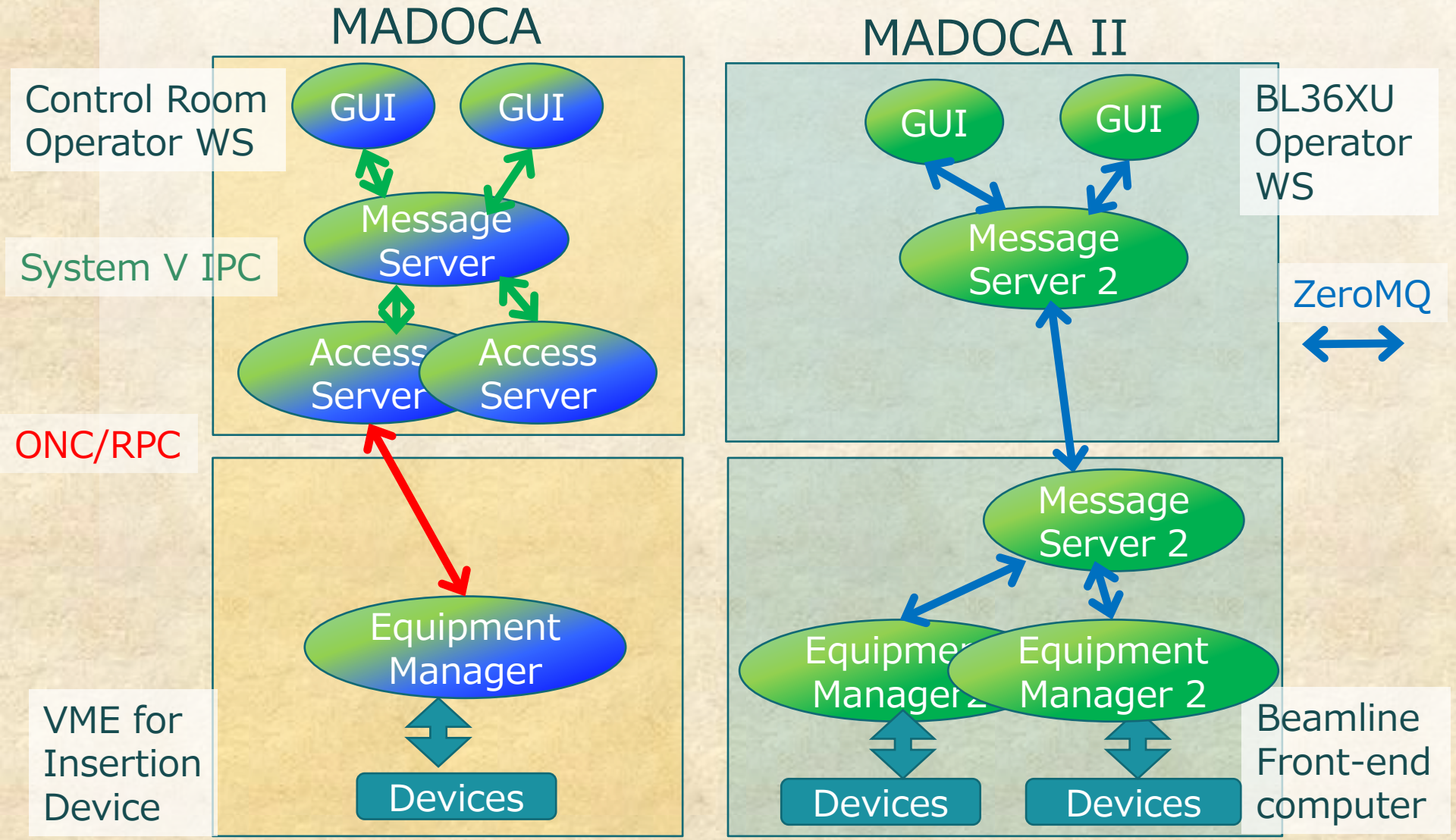

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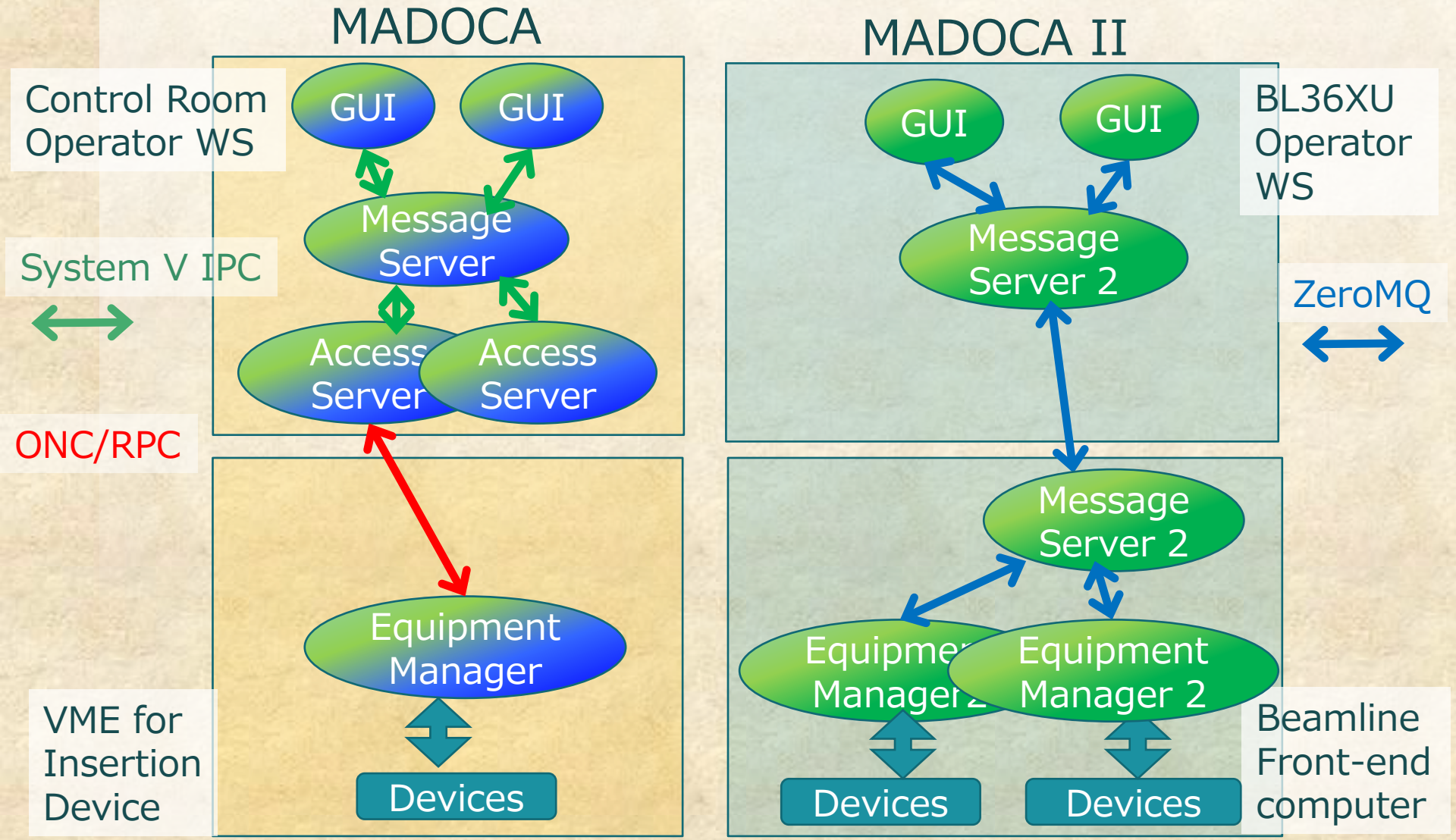

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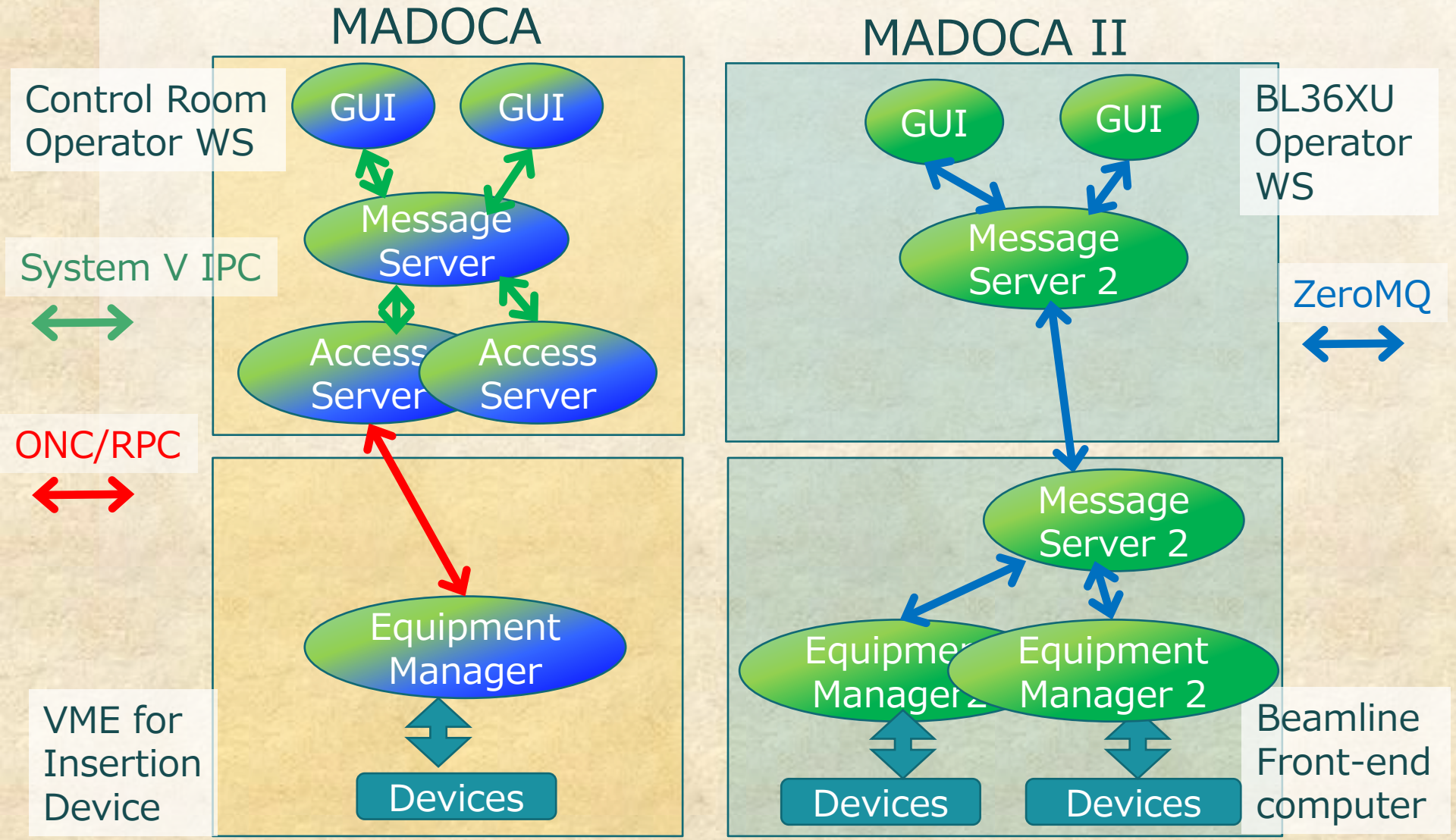

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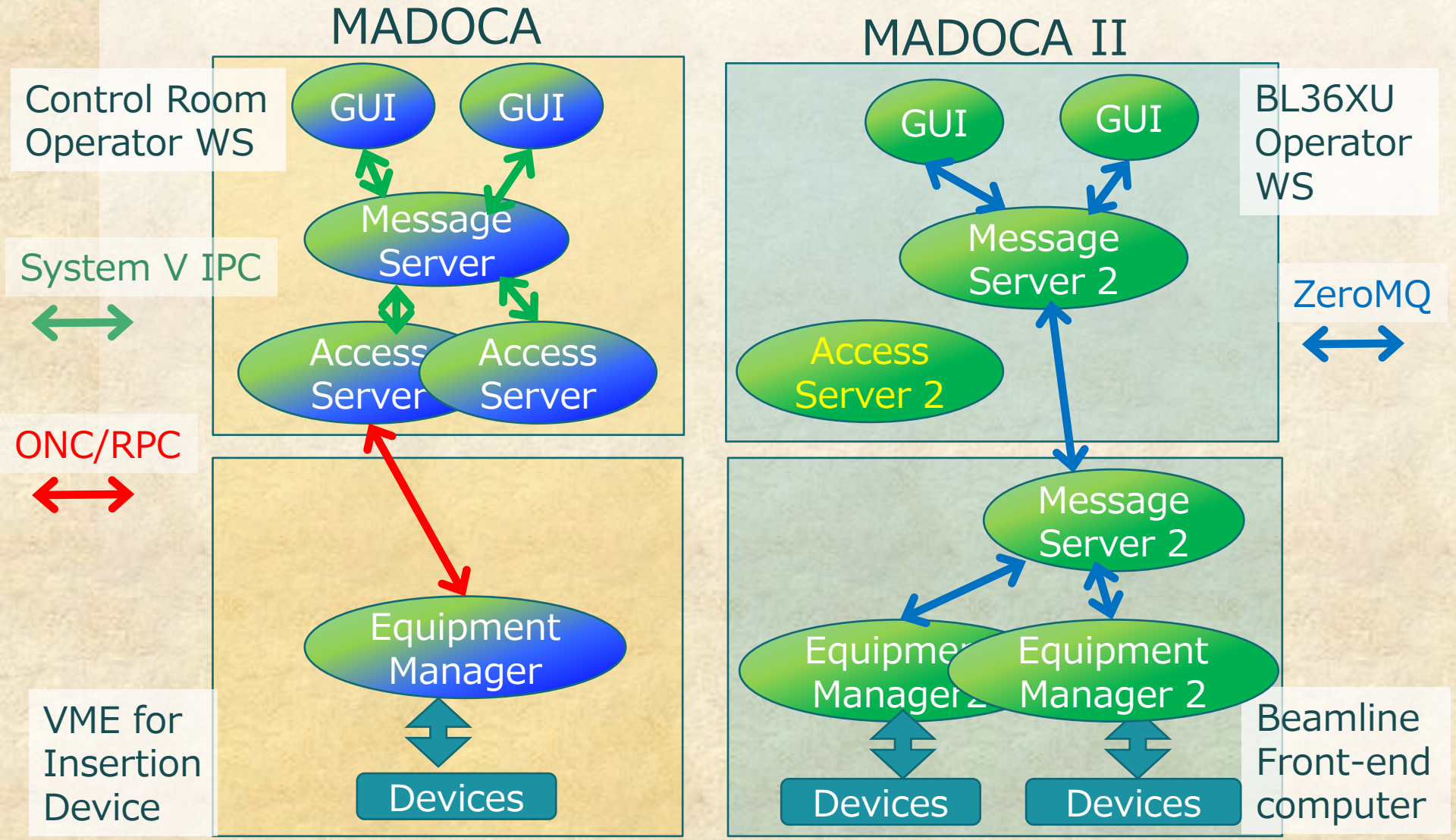

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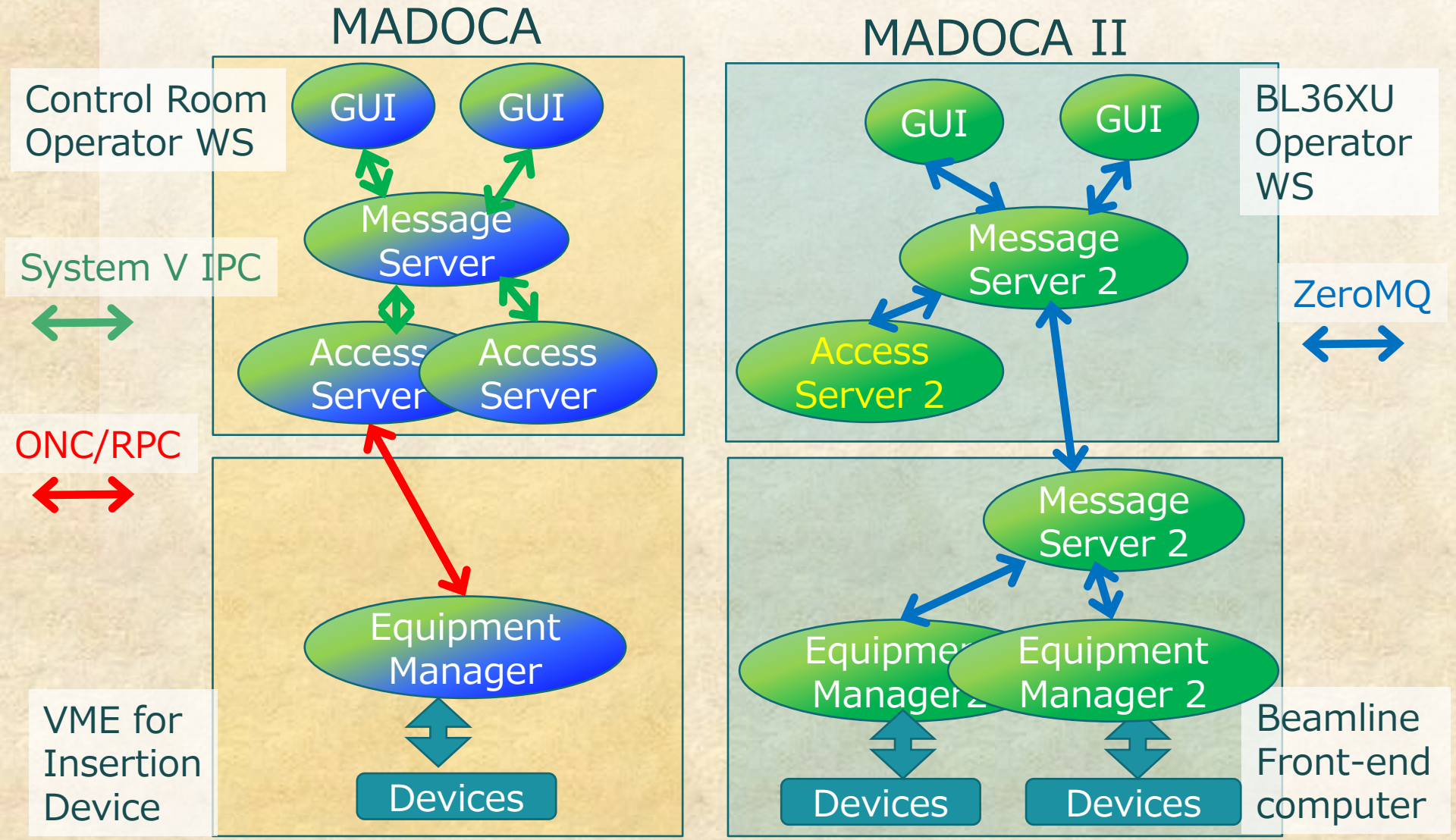

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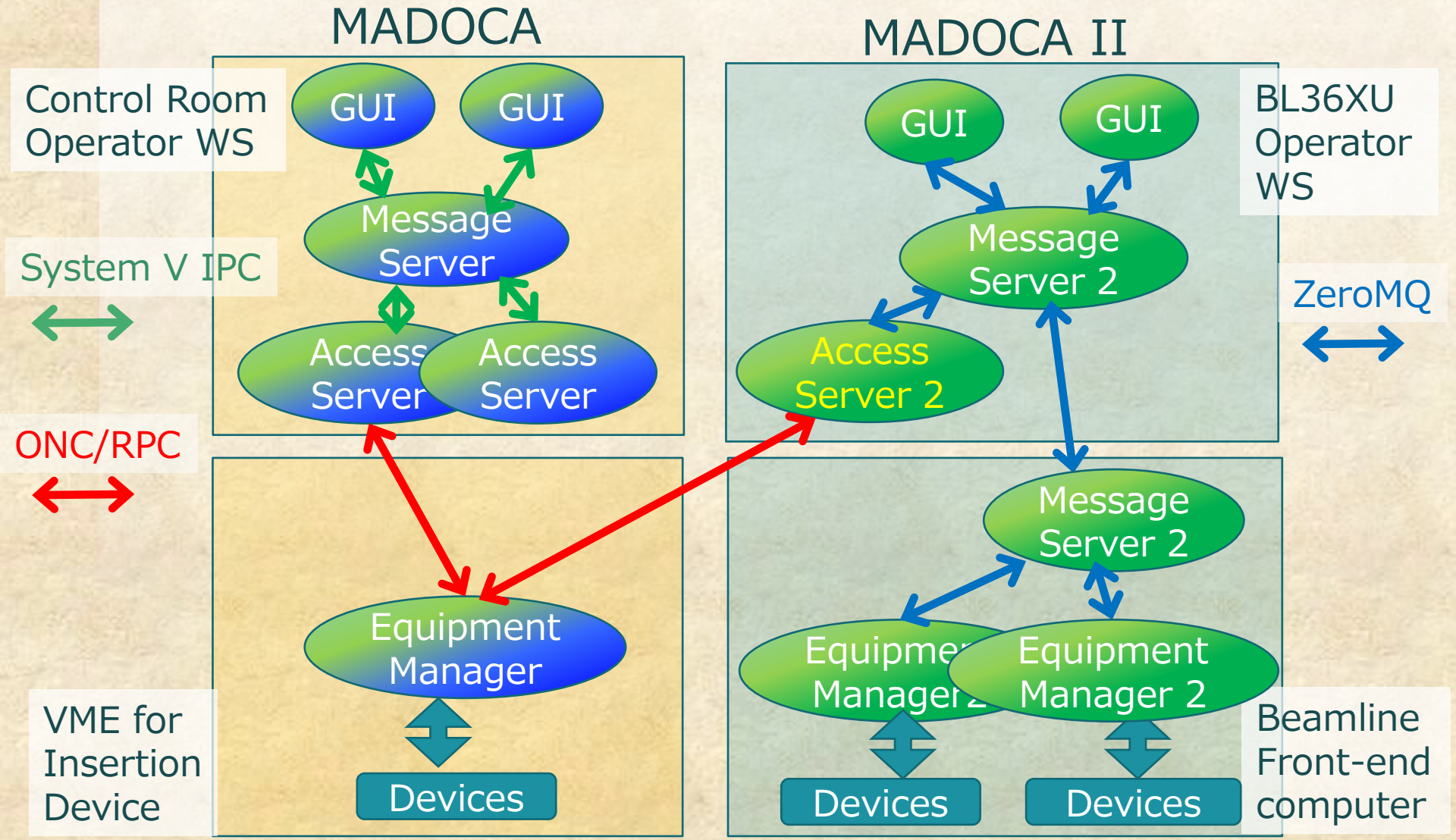

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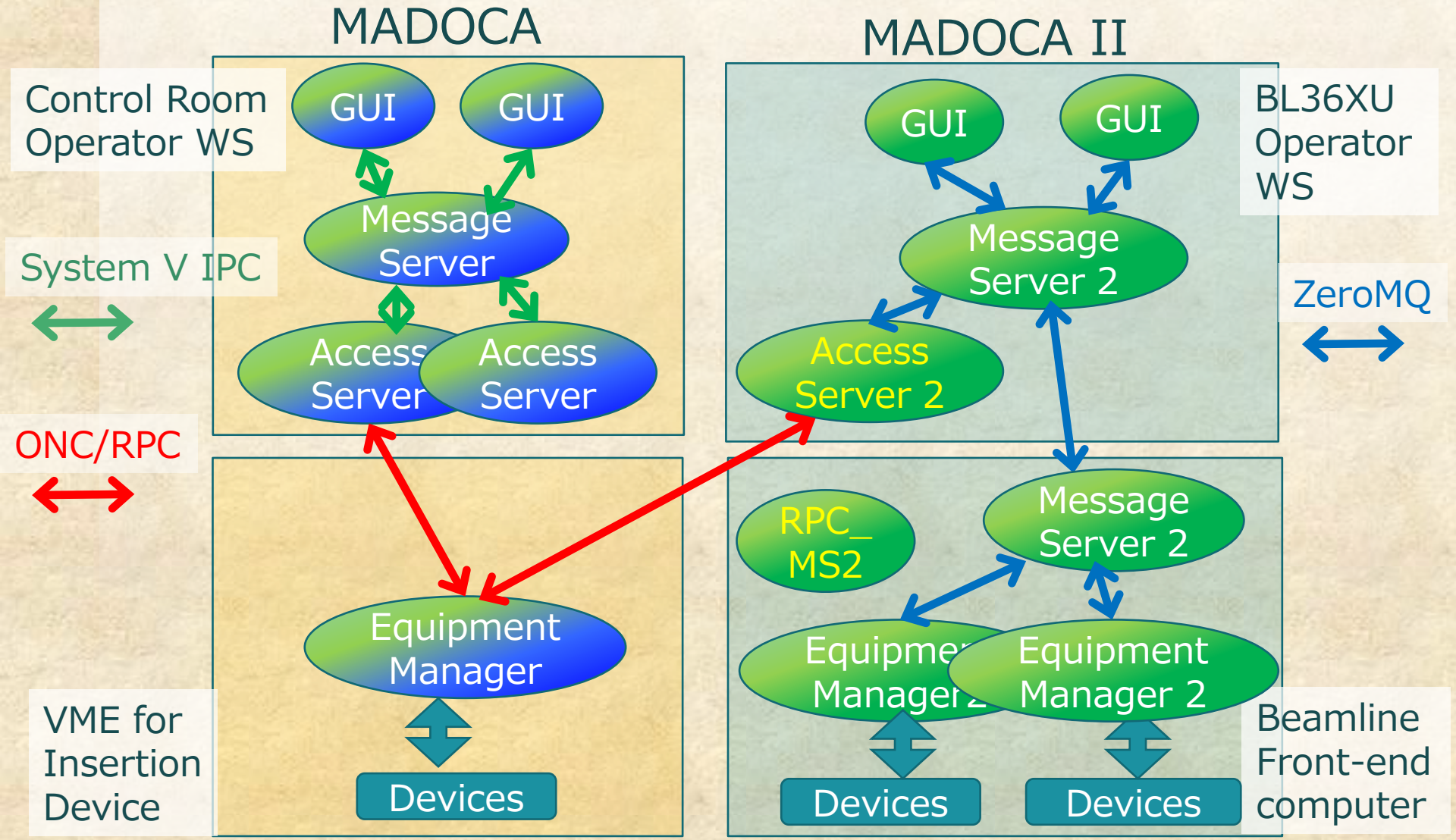

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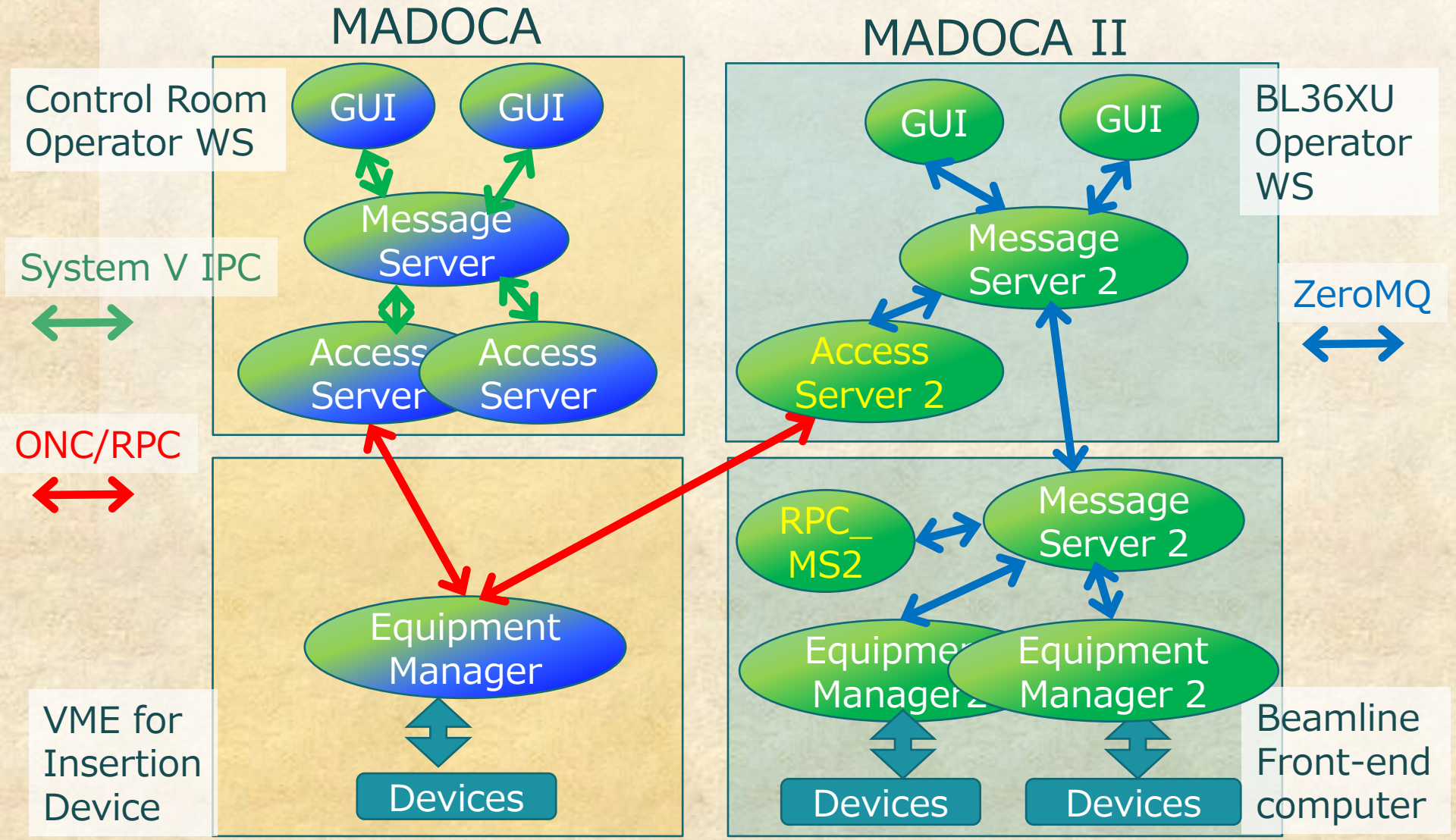

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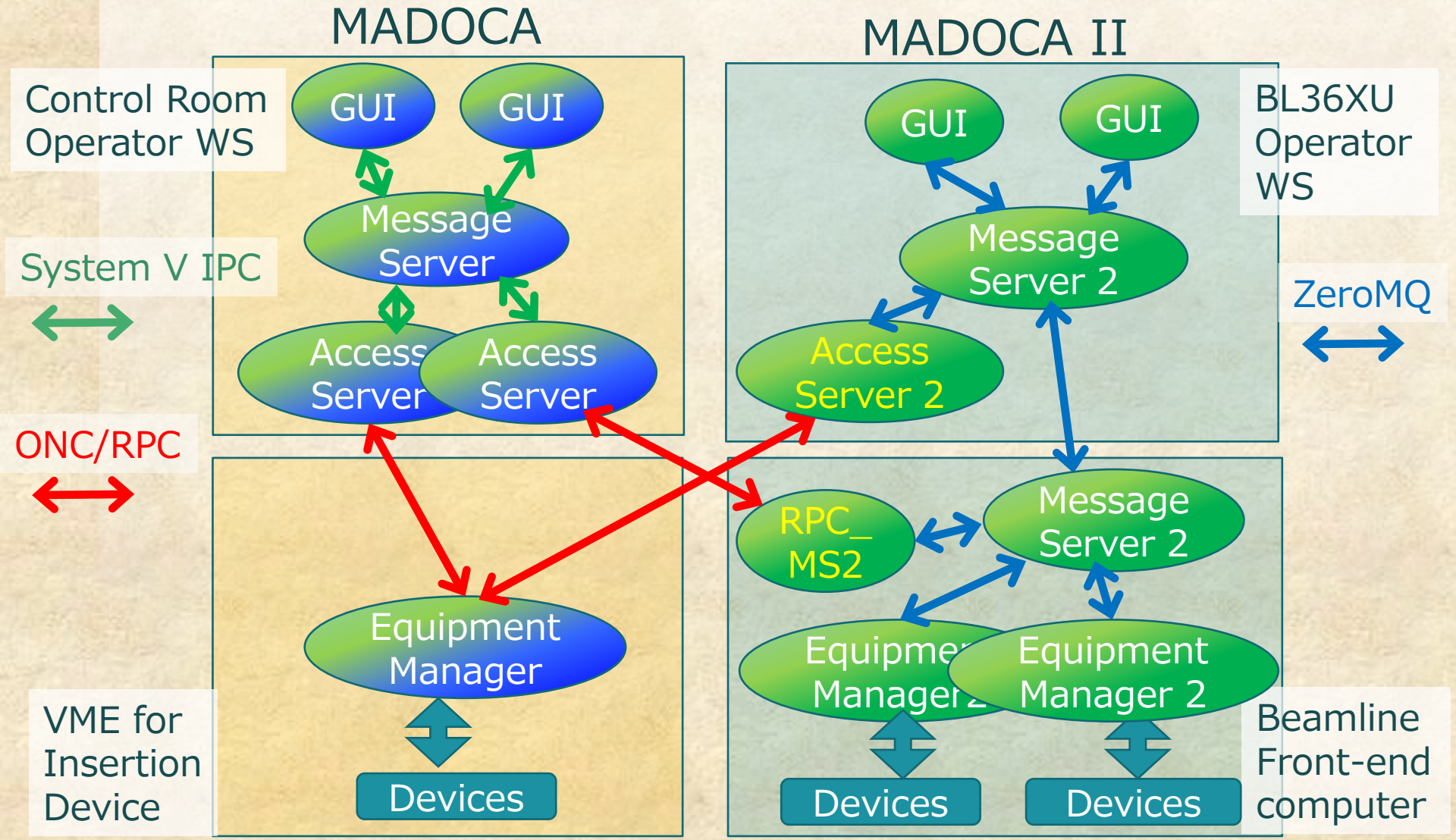
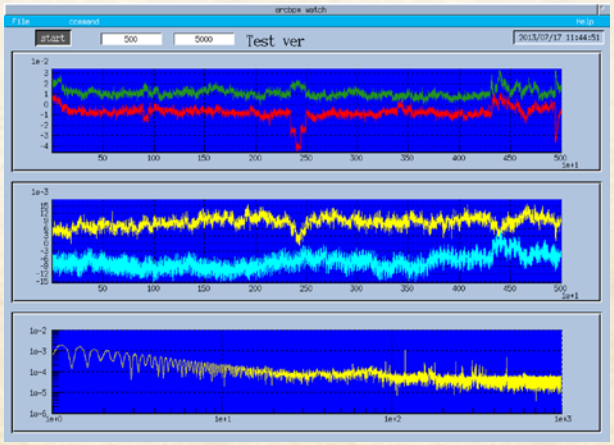


MADOCA II Applications

- "MADOCA II Interface with LabVIEW"
  - MOPPC129　Y. Furukawa et al.
  - Applied to Beam Position Monitor (BPM)
    - Waveform, 20k points/sec
    - Running on Windows
    - LabVIEW protocol for MADOCA II

Applied since Sep. 2013



MADOCA II Applications

- "MADOCA II Interface with LabVIEW"
  - MOPPC129　Y. Furukawa et al.
  - Applied to Beam Position Monitor (BPM)
    - Waveform, 20k points/sec
    - Running on Windows
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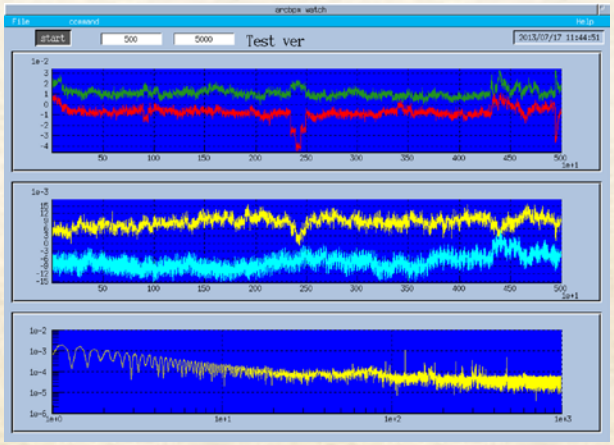

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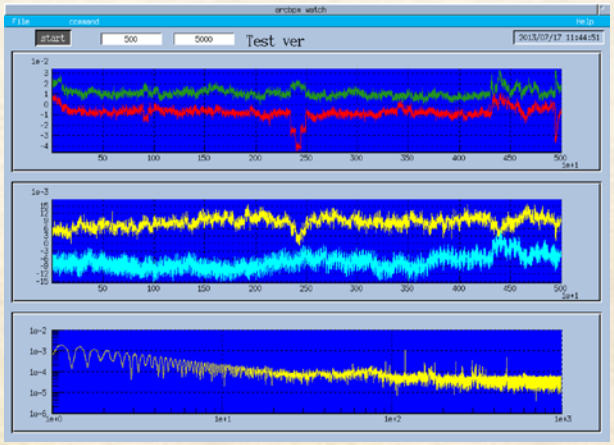

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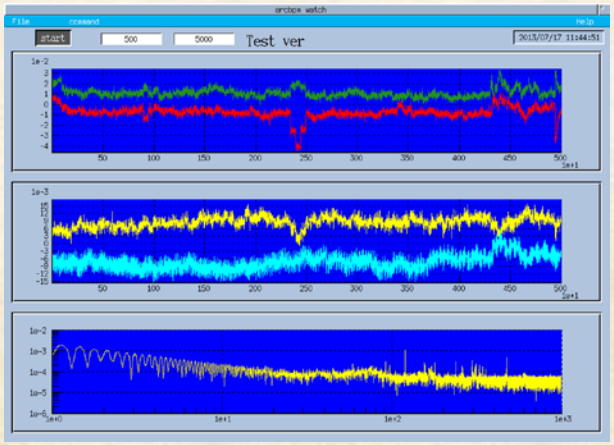

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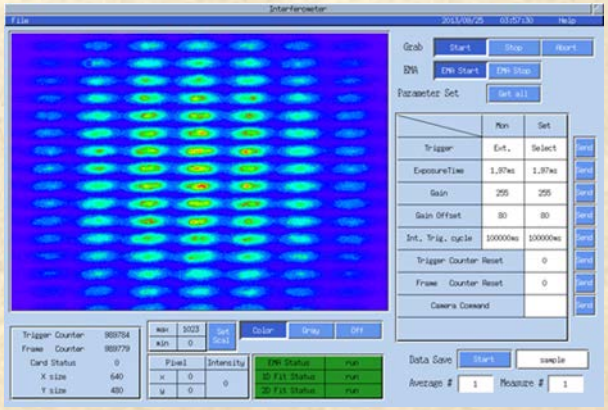

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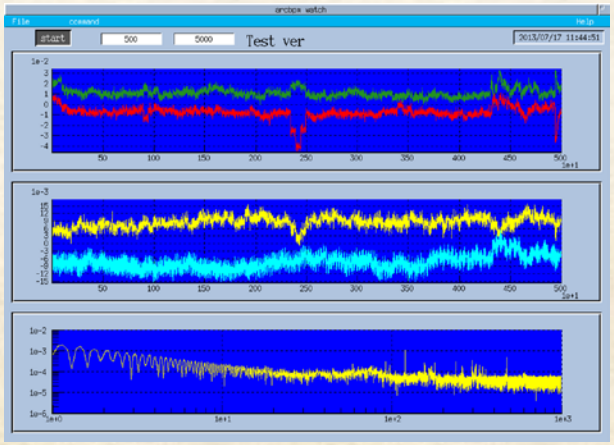

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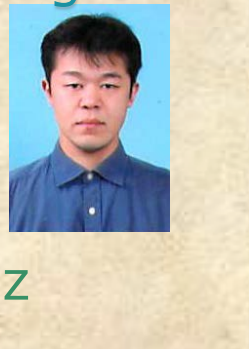
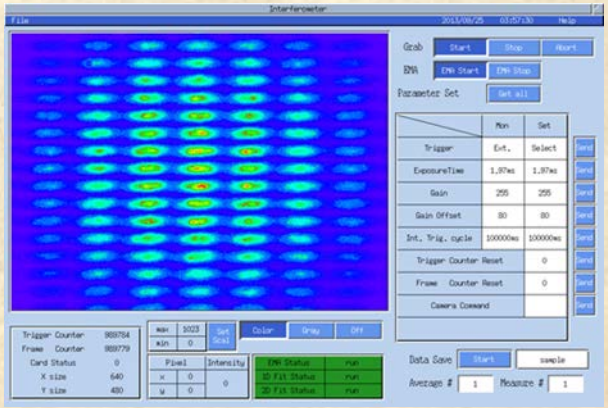
  - TUPPC088 A. Kiyomichi et al.
  - Applied to two-dimensional synchrotron interferometer
    - Image data (VGA), up to 10 Hz





Summary

- New control framework, MADOCA II has been developed
  - Shortcomings in MADOCA are fixed
  - Flexibilities in the Messaging using ZeroMQ/MessagePack
    - Messaging with variable-length data
    - Asynchronous communications
    - Controls on Linux, Solaris and Windows
- Control systems with MADOCA II are implemented
  - Stabilities → confirmed in BL36XU beamline since Sep. 2012
  - BPM and two-dimensional interferometers
  - SACLA experimental station controls

⇨ Since Sep. 2013

- Next step: utilize MADOCA II for various applications
  - Upgrade & Replacement of SPring-8 control systems
  - Apply MADOCA II into other facilities