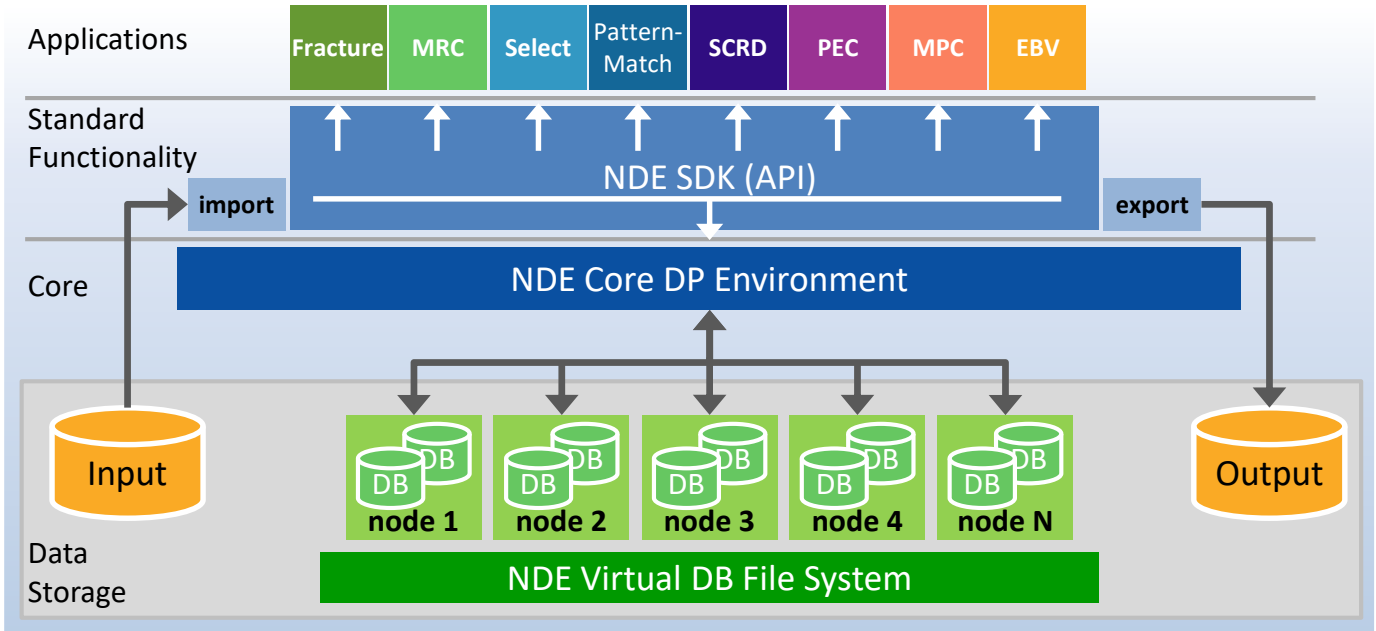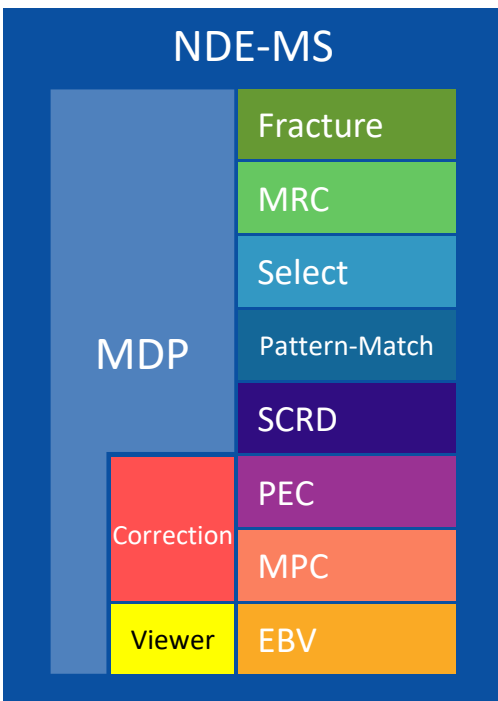# NDE-MS

Product number: w181220

## Total solution for mask data preparation (MDP)

NDE (NCS Distributed Environment) is a distributed processing software package running on a conventional Linux PC-cluster. Its advanced technology realizes more flexible and scalable distributed processing than PATACON PC-cluster.

On the NDE platform, NDE Mask Manufacturable Suite (NDE-MS) is a complete software solution which offers applications required by mask data preparation (MDP), covering post-OPC through pre-mask writing.



## NDE-MS Applications



Various applications are available on NDE-MS.

- ☐ Fracture
  Data fracturing (conversion) including various geometry operations
- ☐ MRC
  Mask rule check
- ☐ Select
  Pattern generation based on geometry operations from existing layers
- ☐ Pattern-Match
  Pattern matching based on templates
- ☐ SCRD
  Shot reduction for Curvilinear/Rectilinear shaped patterns
- ☐ PEC
  Proximity effect correction by dose modulation
- ☐ MPC
  Mask process correction by biasing
- ☐ EBV
  Fast, light, and standalone data viewer

# 1. Product Features

## All processing distributed

With PATACON PC-cluster, one single node takes care of preprocessing (import) and post-processing (export). However, with NDE-MS, all processes are distributed to multiple nodes. In addition, some applications support a pipeline processing which can run the export process simultaneously with them.
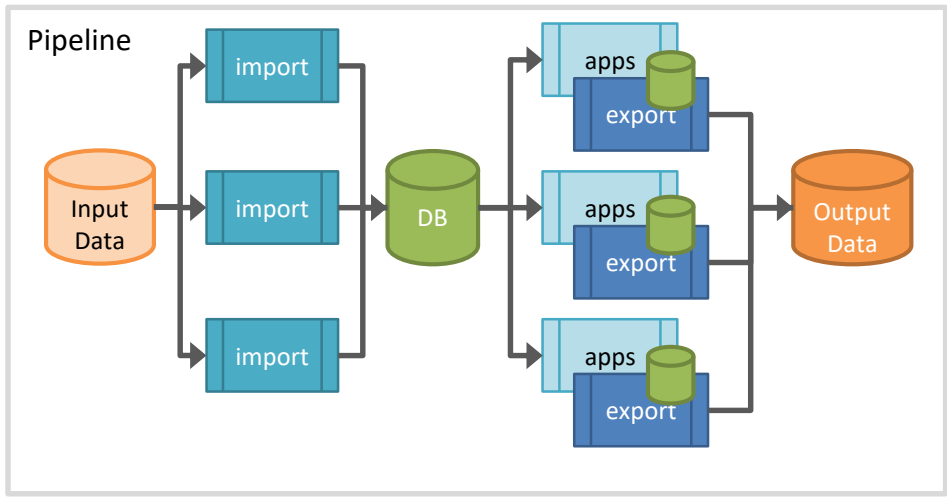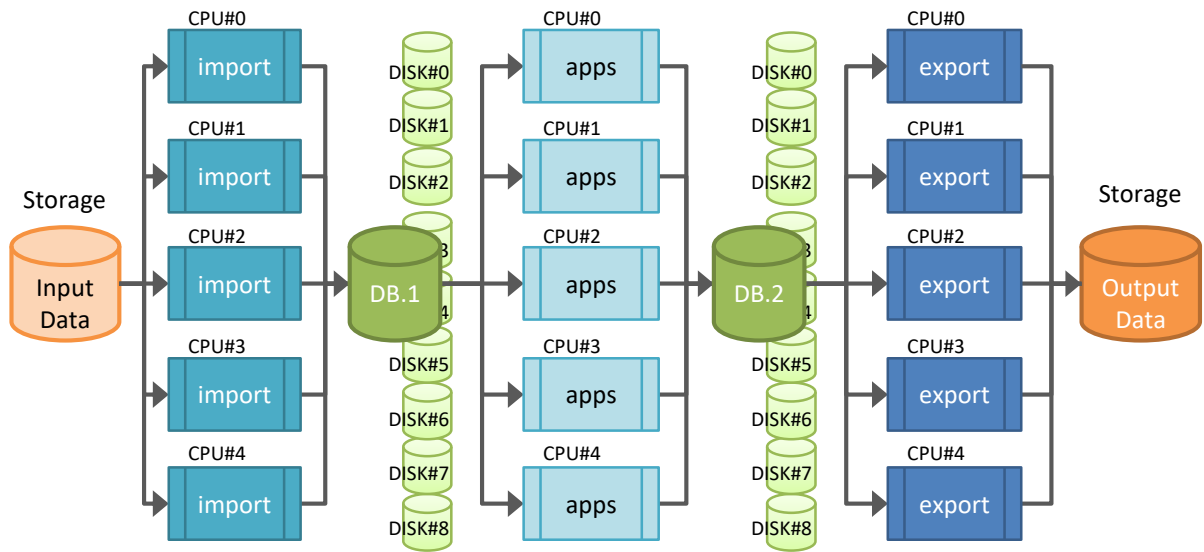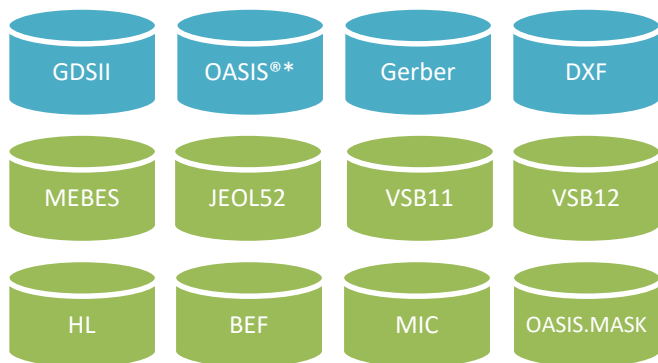


## Outstanding scalability

NDE-MS's advanced distributed processing technology achieves outstanding scalability when increasing CPU cores.



hp22 dram
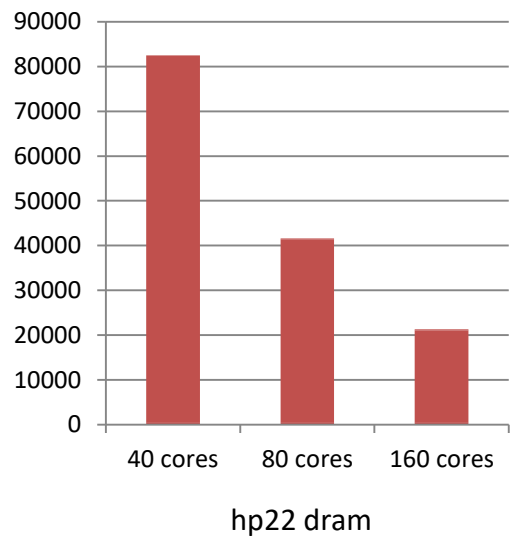
## Plenty of input and output data formats

NDE-MS supports many input and output data formats.

| | | | |
|---|---|---|---|
| GDSII | OASIS®* | Gerber | DXF |
| MEBES | JEOL52 | VSB11 | VSB12 |
| HL | BEF | MIC | OASIS.MASK |

*: OASIS® is a registered trademark of Thomas Grebinski, and is licensed for use by SEMI, San Jose, California.

## Measurement recipe support

NDE-MS supports recipe creation for CD-SEM and Registration tools.

| | | | |
|---|---|---|---|
| LWM90xx | EMU | IPRO | PROVE |

## Task management

A task submitted by a user is called a session and is managed. NDE-MS's flexible task management can run multiple sessions simultaneously. Also, running sessions can be suspended or their priority can be changed.

## Version management

NDE-MS can easily switch versions at any time. For example, a version for production can be set as default, but other versions can be specified when submitting sessions.

## License management

NDE-MS has its own license management so that it does not require a third party's license management system. One license daemon can manage multiple NDE systems, and it can be introduced in a secure environment allowing use of only a specific network port. For those who want to use a third party license management system, NDE-MS also supports FlexLM®.

## Usage result collection

NDE-MS can collect the number of sessions, processing time, the number of figures, data volume, operating time, down time, and availability in the form of daily report, weekly report, and monthly report. In addition, it can also collect information on a specified session. This helps understanding the operation status and allows the gathering of information for accounting purposes.

## NDE-SDK

As an optional feature, an API which accesses an NDE data base (intermediate file) can be provided as a SDK package. Users can implement their own distributed processing application on NDE.
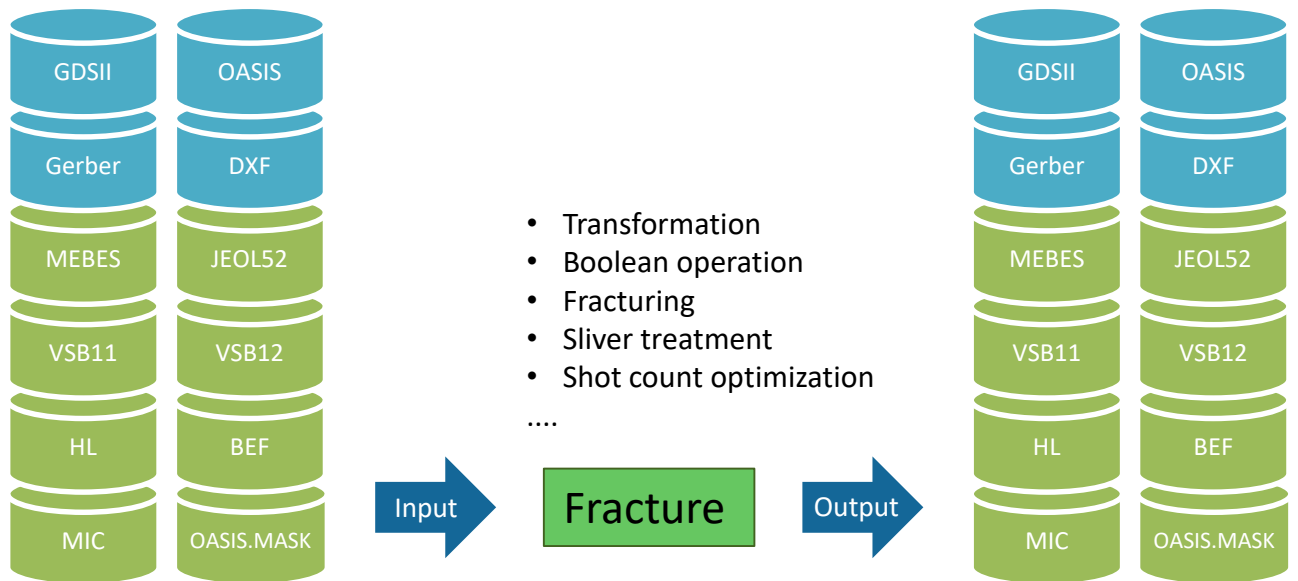
## Plenty of utility programs

Many utility programs are available such as data analysis tools for each data format.

# 2. Applications

## Fracture

Fracture mainly inputs data including jobdeck and does fracturing and data conversion suitable to each mask writer. It can also do various operations such as Boolean operations and sizing.

It can also be used for more advanced processing by cooperating with the other NDE applications.

| GDSII | OASIS |
|---|---|
| Gerber | DXF |
| MEBES | JEOL52 |
| VSB11 | VSB12 |
| HL | BEF |
| MIC | OASIS.MASK |

- Transformation
- Boolean operation
- Fracturing
- Sliver treatment
- Shot count optimization

....

**Input** → **Fracture** → **Output**

| GDSII | OASIS |
|---|---|
| Gerber | DXF |
| MEBES | JEOL52 |
| VSB11 | VSB12 |
| HL | BEF |
| MIC | OASIS.MASK |

### Fracture

- Transformation
  - mirror, rotate, scale, etc.
- Boolean operation
- Fracturing
- Sliver treatment
- Shot count optimization
- Uniform biasing
- Rule-based biasing
- Data compaction
- Verification
- Density, density map calculation
- Various utility programs

and more.

MRC stands for Mask (or Manufacturability) Rule Check, and it checks manufacturing rules on mask data. Because MRC can detect geometries matching specified rules, it can help finding problems in advance of mask writing.

Furthermore, the MRC engine can extract specific pattern types such as scattering bars (SB). Special processing can be applied to the extracted specific pattern by cooperating with Fracture engine.
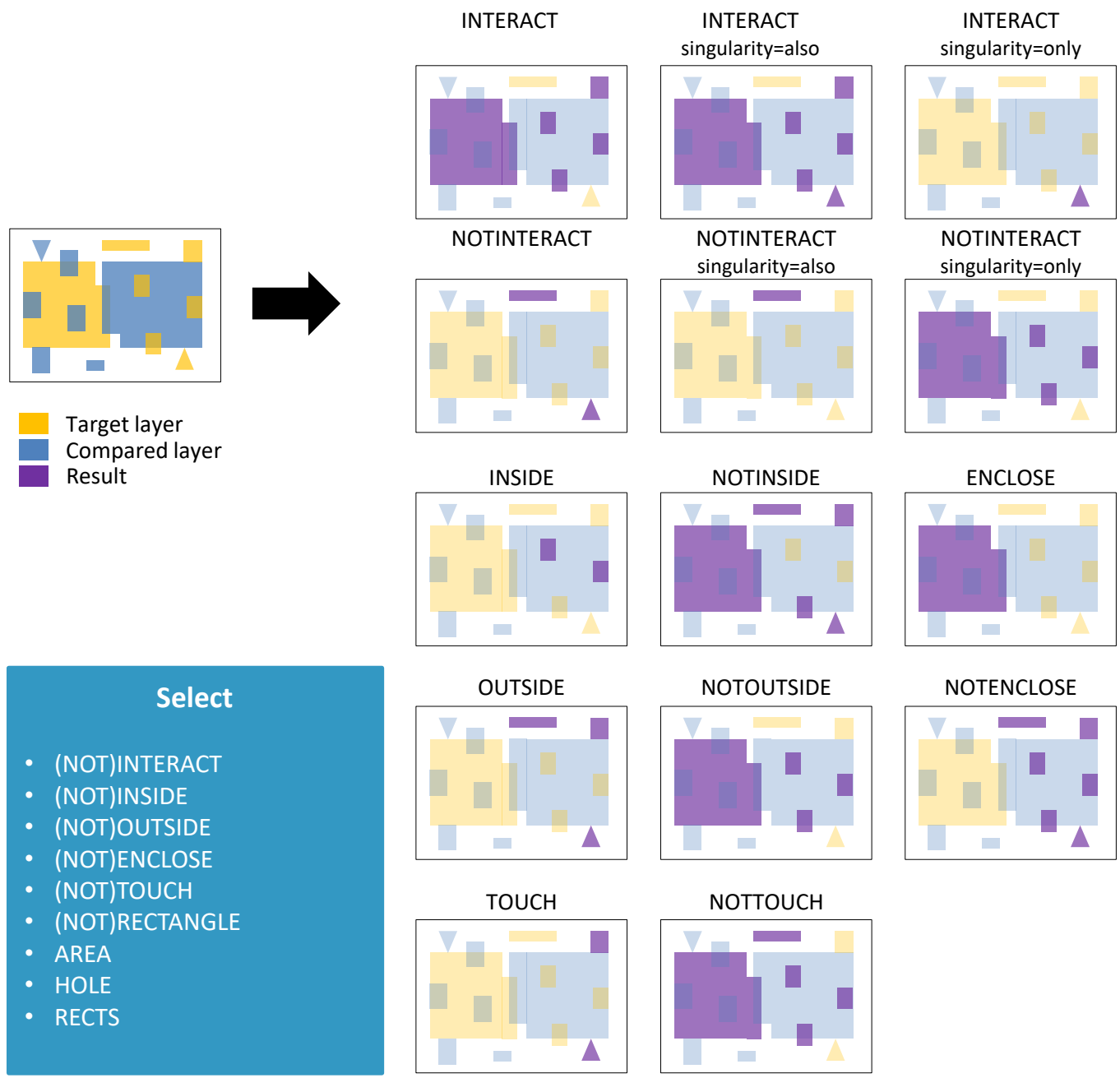
### WIDTH/SPACE

### WIDTH/SPACE w/ notch

(removed)

### BBOX

### SB

### Area

10 um²

7.2 um²
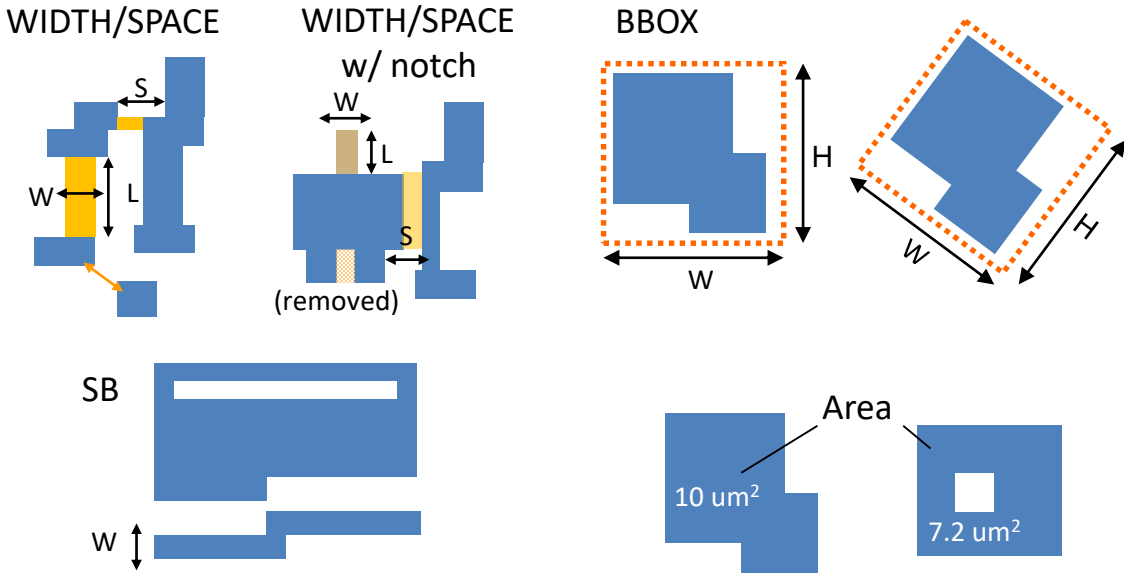
### MRC

- Width/Space detection
- Detection by bounding box / area
- SB / rectangle extraction
- Angle / angled line detection
- Multiple exposure detection
- Difference detection
- Classification of detection result
- Rule filtering
- CSV output
- Geometry output

and more.

BOX

(distance)

(length)

W

(distance)

BAR

(distance)

length
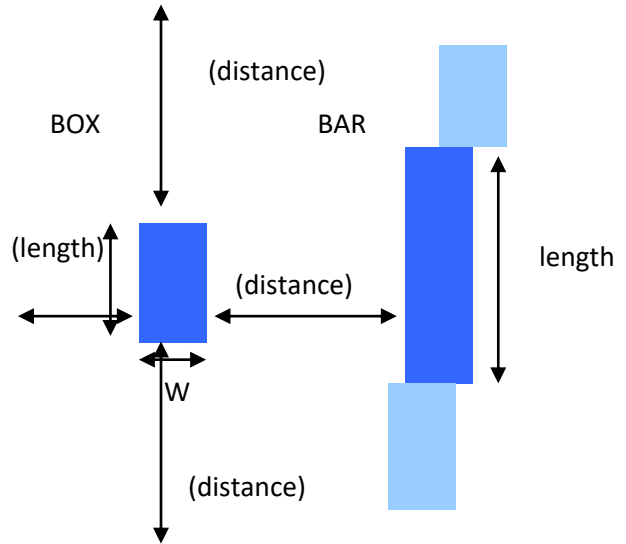
## Select

Select can generate new pattern data by choosing data matching a given condition. This is also called layer composition and is done through cooperation with the Fracture engine.



Target layer
Compared layer
Result

### Select

- (NOT)INTERACT
- (NOT)INSIDE
- (NOT)OUTSIDE
- (NOT)ENCLOSE
- (NOT)TOUCH
- (NOT)RECTANGLE
- AREA
- HOLE
- RECTS

INTERACT

INTERACT
singularity=also

INTERACT
singularity=only

NOTINTERACT

NOTINTERACT
singularity=also

NOTINTERACT
singularity=only

INSIDE

NOTINSIDE

ENCLOSE

OUTSIDE

NOTOUTSIDE

NOTENCLOSE

TOUCH

NOTTOUCH

## Pattern-Match

Pattern-Match extracts pattern groups matching a template. The template can be created by EBV. When it performs a match, transformations such as mirroring, rotating, and scaling, and the difference of shape by OPC are taken into account. Moreover, if measurement information is added when the template is created, it finds a match and takes the measurement simultaneously. Special processing can be applied to the matched specific pattern by cooperation with the Fracture engine.



Input Data

Template

Point2

Point1

Extracted patterns
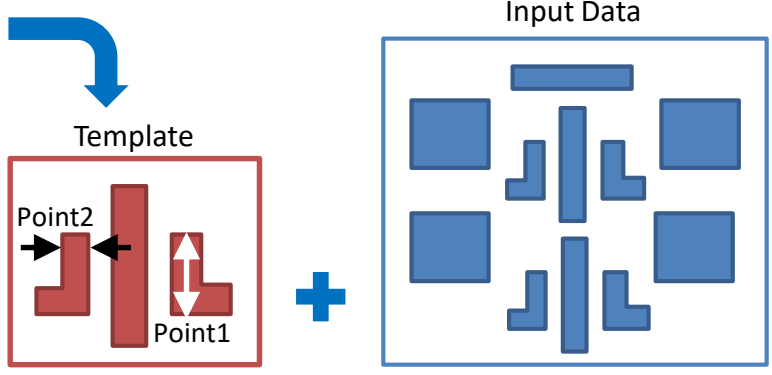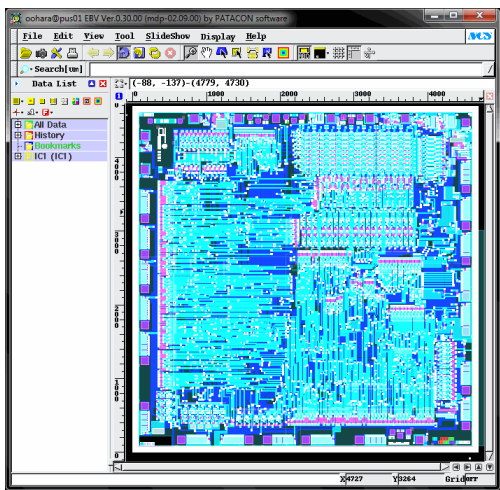
### Pattern-Match

- Template creation
- Perfect matching
- Transformation aware
  - mirror, rotate, scale
- OPC aware
- Measurement
- CSV output
and more.

Measurement result

CSV
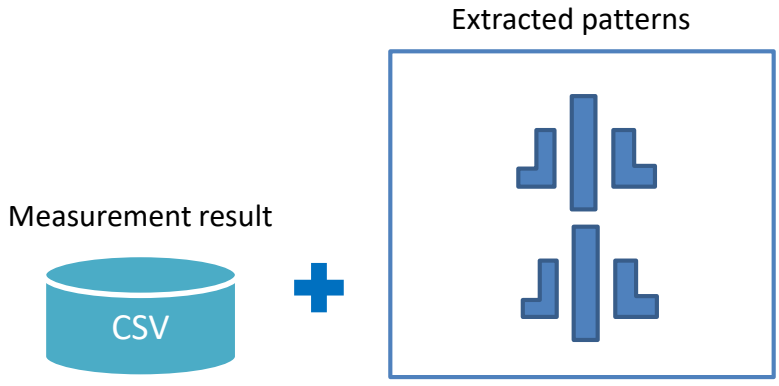
## SCRD

SCRD is an application which reduces the number of shots for mask writing. It is gathering attention as a data optimization prior to fracturing because the pattern size is getting smaller and the mask writing time is increasing.

SCRD has two applications. One is SCRD-R for rectilinear patterns with conventional OPC applied. Another is SCRD-C for curvilinear patterns with ILT applied.

## SCRD-R

SCRD-R reduces the number of shots by removing jogs, notches, and bumps by considering the shot size and the change of contour due to mask writing.
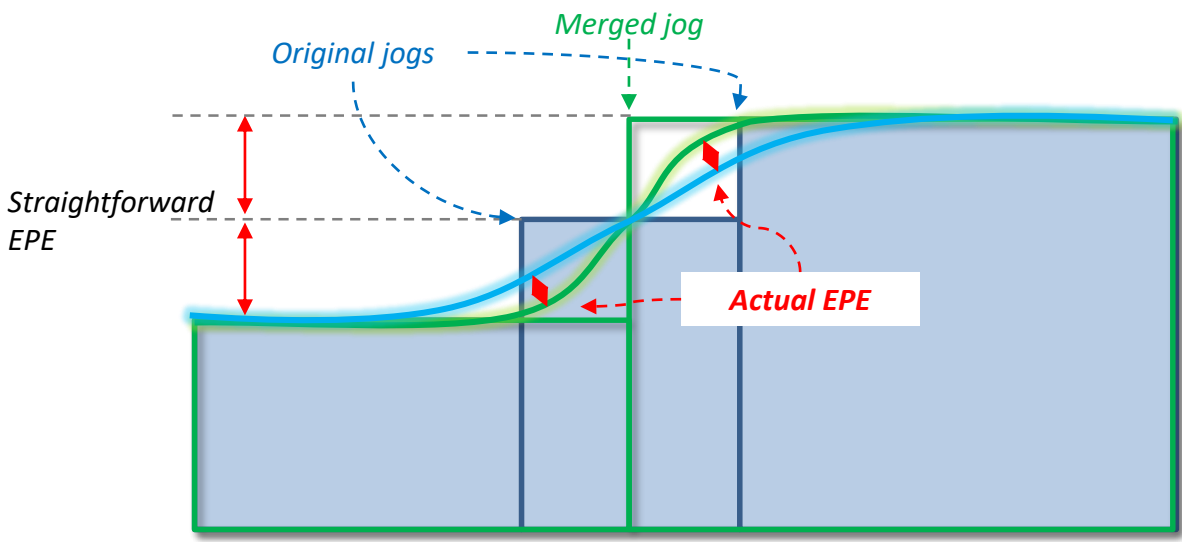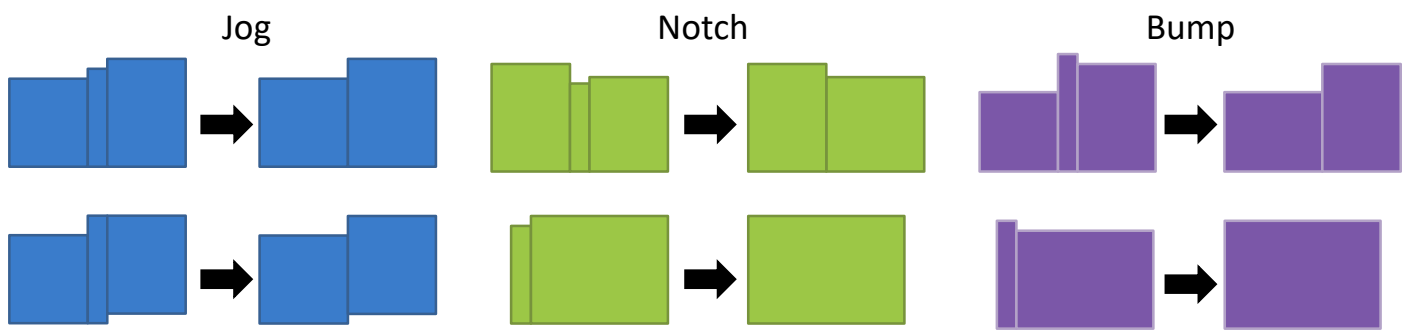
## SCRD-C

SCRD-C places rectangles based on the curved line of ILT. The placement of rectangles is done on a rules basis. It can drastically reduce the number of shots compared to a rectangle placement by conventional fracturing.



Property Extraction → Classification → Shot Generation

Overlap shots

Non-overlap shots
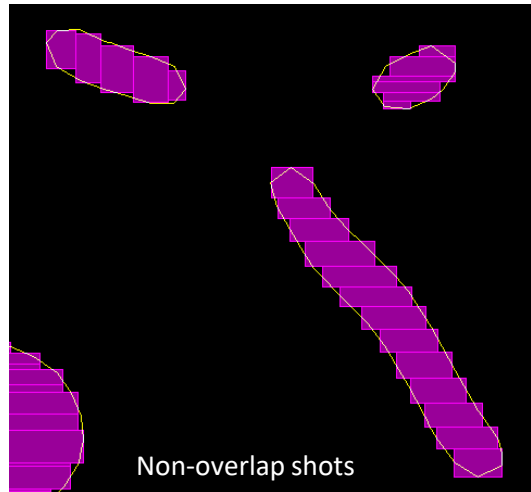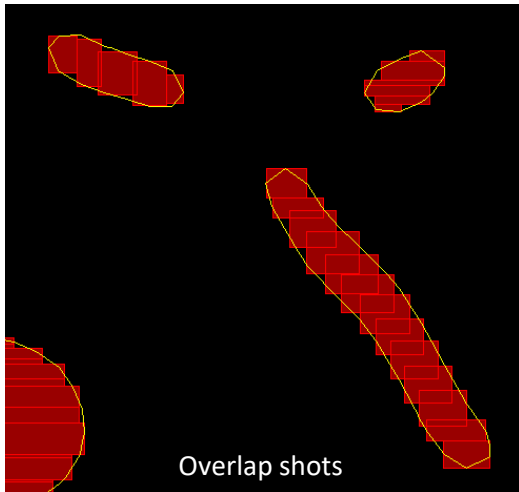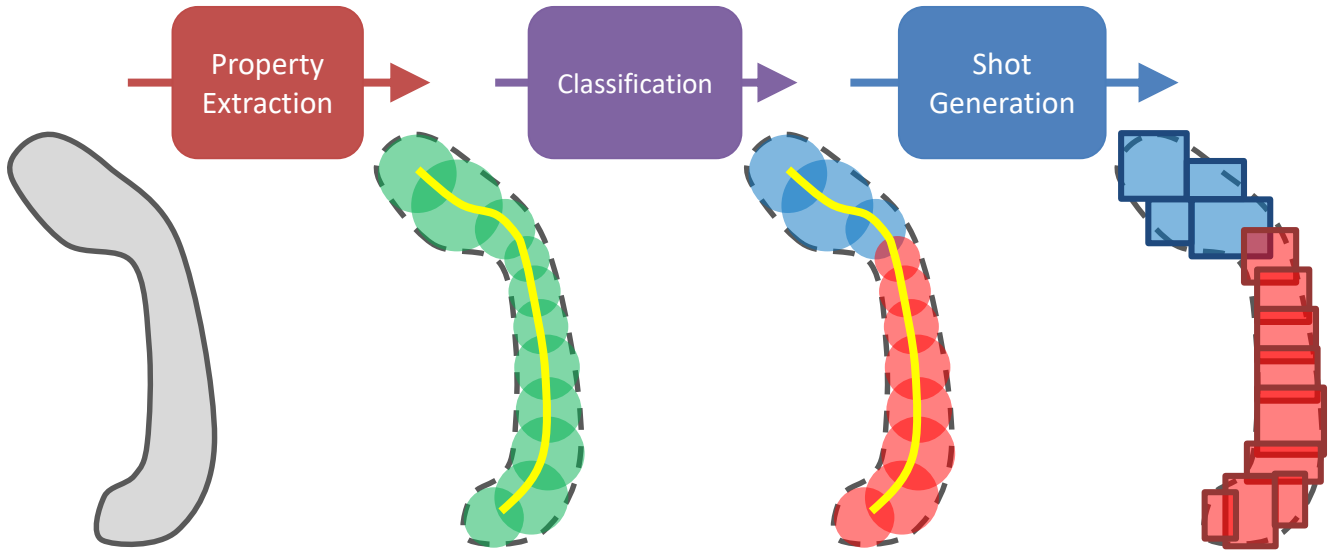
PEC stands for Proximity Effect Correction and it corrects the proximity effect of electron beam using a threshold model. The proximity effect correction for photomasks is gathering attention because the pattern size is getting smaller and because of EUV mask complexity.
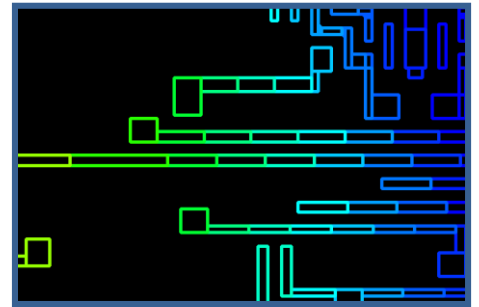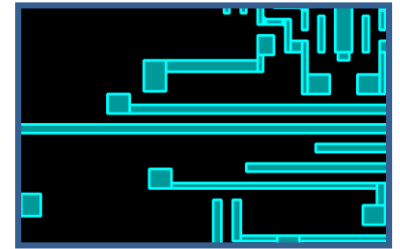
PEC can consider either backscattering, forward scattering, or both. It also consider a short range backscattering observed by a study of EUV masks. These effects are corrected by dose modulation or biasing.
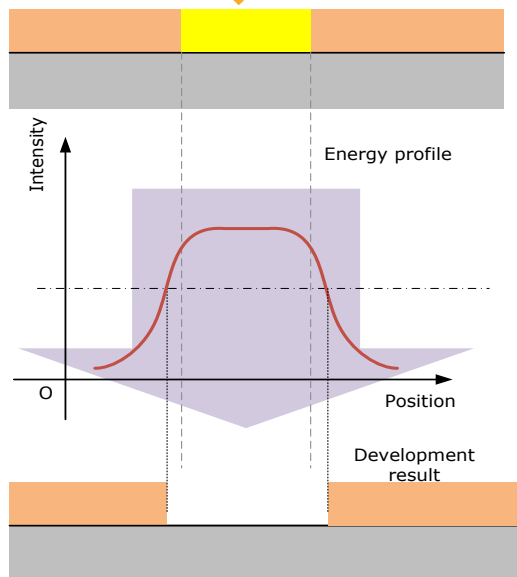
- Double Gaussian PSF

$$psf(r) = \frac{1}{1+\eta}\left(\frac{1}{\beta_f^2}\exp\left(-\frac{r^2}{\beta_f^2}\right) + \frac{\eta}{\beta_b^2}\exp\left(-\frac{r^2}{\beta_b^2}\right)\right)$$

- PSF for EUV mask writing (Example)

$$psf(r) = \frac{1}{1+\eta+\nu}\left(\frac{1}{\beta_f^2}\exp\left(-\frac{r^2}{\beta_f^2}\right) + \frac{\eta}{\beta_b^2}\exp\left(-\frac{r^2}{\beta_b^2}\right) + \frac{\nu}{\beta_c^2}\exp\left(-\frac{r^2}{\beta_c^2}\right)\right)$$
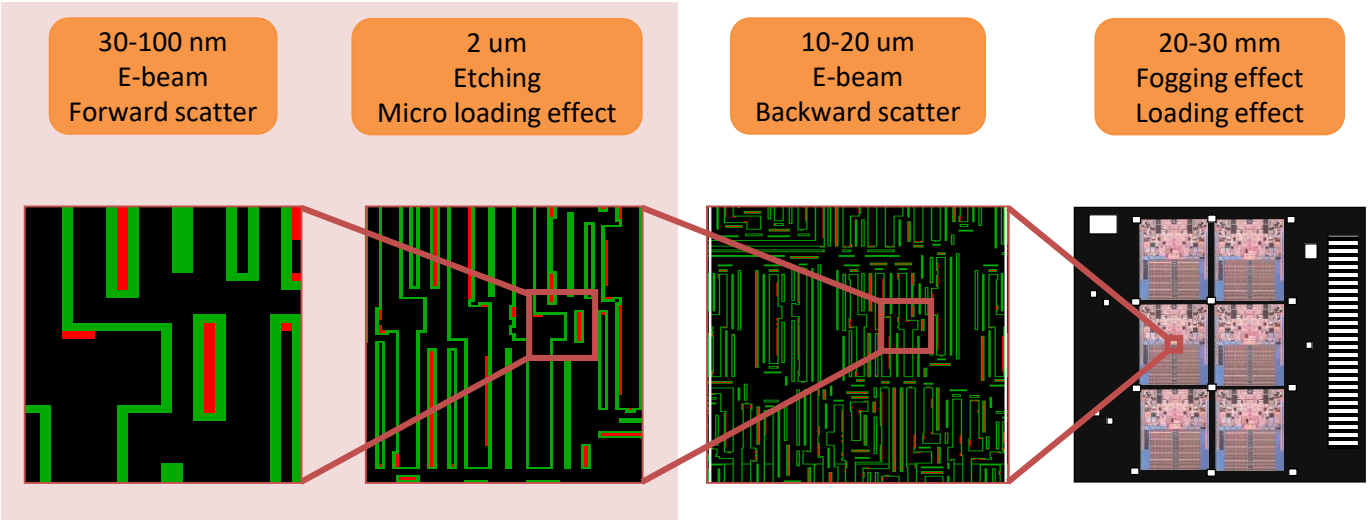


Example of dose modulation

## PEC

- Threshold model
- Arbitrary PSF setting
- Forward scattering correction
- Dose modulation
- Basing
- Energy verification
- (Spot beam support)

and more.



Threshold model

## MPC

MPC stands for Mask Process Correction, and it mainly corrects micro loading effect of etching and forward scattering proximity effect of the electron beam using a model basis. The mask process correction is gathering attention because the pattern size is getting smaller and because of EUV mask complexity. MPC corrects those effects by biasing. The proximity effect correction for forward scattering uses the same model as the PEC engine.

| 30-100 nm E-beam Forward scatter | 2 um Etching Micro loading effect | 10-20 um E-beam Backward scatter | 20-30 mm Fogging effect Loading effect |



### MPC

- Model calibration
- Feed forwarding
- Process delay adjustment
- MPC (Correction process)
- MPC to assist features only
- Process emulation
- Topology check

and more.

Without MPC

With MPC



Not resolved
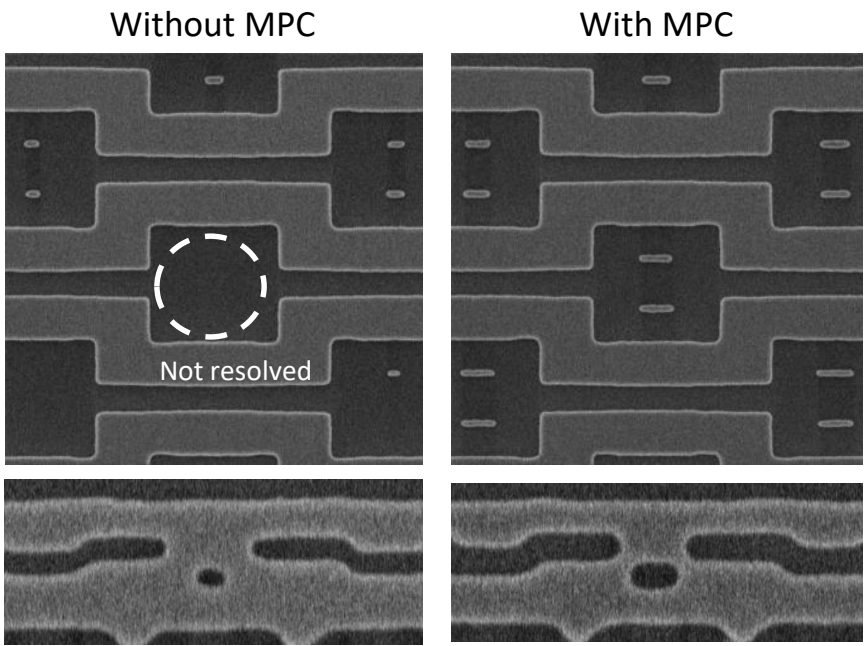
EBV is a data viewer which can display various data formats including jobdecks. It has features such as fast, precise, direct display without intermediate files, unlimited open files, and more. It can also do various operations such as measurement and density calculations to the data displayed. In addition, it supports recipe generation for CD-SEM and Registration tools.
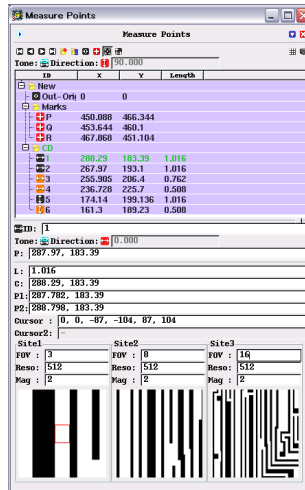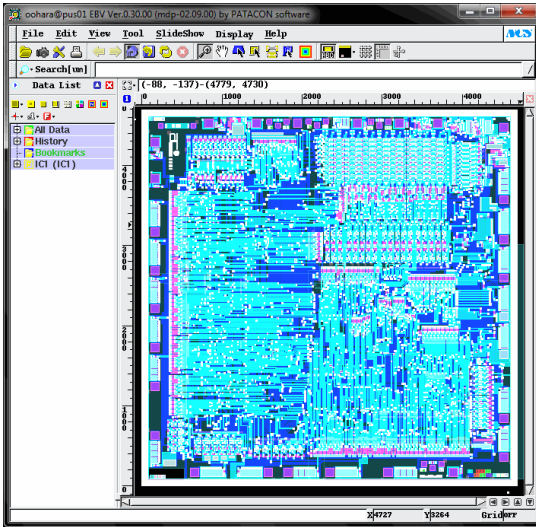




CD-SEM/Registration support

Recipe
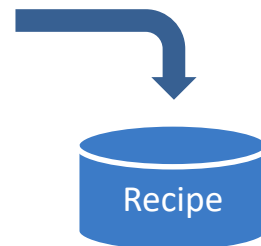
## EBV

- Various data display
- Cache file
- Chip / cell line display
- Cell coloring
- Highlighting
- Hatching
- Transformation
  - mirror, rotate, scale, etc.
- Data header / figure count display
- Cell tree display
- Density, density map calculation
- Figure information display
- Cell display
- Measurement
and more.

*CAD Data*
- GDSII
- GERBER

*EB Data*
- MEBES
- JEOL52
  (v1, v1.1, v2.1, v3, v3.1)
- HL
  (700, 800, 900, 7000)
- VSB (11, 12)
- BEF
- MIC

*SEMI*
- P39 (OASIS)
- P44 (OASIS.VSB/MASK)

Inspection Data
- LM7000
- DM (NPI-5000)

*EB Data*
- MEBES (JB)
- MEBES Extend (eJB)
- JEOL (JDK)
- JEOL Express (JDF)
- VSB11 (MDS)
- VSB12 (MDS2)
- MIC (MS)
- HL (Lot)
- HL700 (JTX)

*SEMI*
- SEMI-P45 (Maly)
- SEMI-P10 (Text)

*Metrology support* (optional)
- Vistec LWM90xx
- Holon EMU
- KLA iPRO
- Zeiss PROVE

# 3. Deployment Guide

## Operation environment

This software operates in a cluster environment in which one master node connects with several to some hundreds client nodes by a high-speed network.

- ◻ Operating system　　　　: Red Hat Enterprise Linux (CentOS) 4, 5, 6 (x86_64)
- ◻ Install destination　　　 : NFS directory shared by the master and all client nodes
- ◻ Communication ports　　 : 4 ports (default: 10004, 10005, 20006, 20007)
- ◻ CPU　　　　　　　　　 : The highest frequency per core is always recommended.
- ◻ Memory　　　　　　　　: Min. 2GB/core　(Recommended: 4GB/core @32bit、8GB/core @64bit)
- ◻ Local disk　　　　　　　: Min. 100GB/node　(Recommended: 500GB/node)
- ◻ Network　　　　　　　　: Min. 1Gbps　(Recommended: 10Gbps)



Master node

Client node
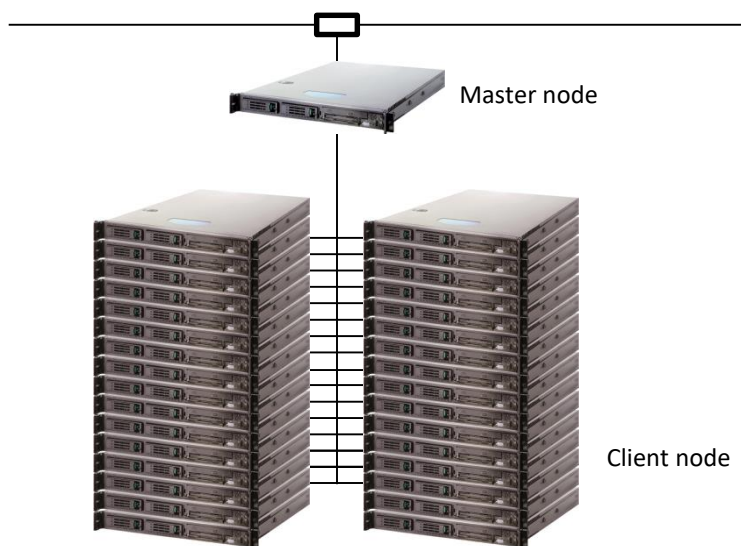
## Software license

- ◻ Software license fee
  The license fee is determined by **the number of applications, data formats, and CPU cores**. Contact us for detail.

- ◻ License style
  The license is a time basis which offers the maintenance and a nonexclusive license to use the software during the period of contract. Contact us if interested in a perpetual license (maintenance license for 2nd year or later).

- ◻ Sales style (example 1): Software sales only
  NCS installs the software on a hardware system prepared by the customer. An installation fee may be charged to guarantee the software running.

- ◻ Sales style (example 2): Software + hardware recommended by NCS
  NCS installs the software on a hardware system recommended by NCS and purchased by the customer and delivers it to customer as a system. As long as the vendor maintenance is continued, NCS offers the 1st maintenance for the hardware.

- ◻ Sales style (example 3): Software sales + hardware selected by customer
  NCS installs the software on a hardware system selected and purchased by customer and delivers it to customer as a system.

System specifications are subject to change without notice for improvement.

Development and sale:   Nippon Control System Corporation

- Head Office:
  1-19-15 Ebisu, Shibuya-ku, Tokyo, 150-0013, Japan
  tel: +81-3-3443-5081 fax: +81-3-3443-5189

- Shin-Yokohama Office:
  2-7-9 Shin-Yokohama, Kouhoku-ku, Yokohama-shi, Kanagawa, 222-0033, Japan
  tel: +81-45-477-5800 fax: +81-45-477-5811

For this product, please contact the Shin-Yokohama Office.
Email: ncs-patacon@nippon-control-system.co.jp

Product number: W181220 (Content of this catalog: as of January, 2014) P20-5M11M-J