E3 : New ESS EPICS Environment II

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Fear for E3

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Fear is the path to the dark side...fear leads to anger...anger leads to hate...hate leads to suffering.

Yoda

Dynamic module for EPICS : EEE, PEE[1], or E3

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- Quality management of IOCs
  - full freedom: good for small groups; not so good for broad provider such as ICS to many instrument developers and in-kind developers
- Common quality management problems:
  - varying quality of modules (open source): code, documentation, & styles
  - version changes of base, modules, etc.
  - platform variability
  - inconsistent version management overall in EPICS community
- Have to consider different EPICS users over ESS life time
  - advanced users: can manage their own IOC details
  - device integration focused (time limited) users: want to avoid low level development, compiling code etc.
  - less experienced users : benefit from pre-selection and prepared modules
  - core development users

[1] Unofficial name: **P**SI **E**PICS **E**nvironment

Its Benefits

- for users: avoid re-building IOCs from scratch
  - interesting for integration focused, and less experienced users
  - some IOC development effort shifts from those to core development users
- widely accepted versioning practices are realized in the ESS EPICS development,
- incompatible version combinations should be avoided if we carefully define what/how we want to use
- migration process over EPICS base versions is less likely to cause problems

This Talk is ...

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to do ..

- to describe the current status on the **E3** Development based on the former presentation
- to show how we can duplicate **E3** on one Linux flavor (Debian 8)
- to explain shortly the new building system for **E3**
- to show the real example for the building and loading an IOC

not to do

- not to explain what the current EEE/PEE problems are, and how to resolve them
- not to explain what EPICS is and how to use it
- not to cover all technical aspects in ESS-0214598 (first presentation about E3)

Let It Build While ...

```
$ git clone https://github.com/icshwi/e3

$ bash e3.bash -g jhlee all
```

Why Environment is Needed

EPICS Base

Version 7

core
ca
database
libCom

Version 3

normativeTypes
pvAccess
pvData
pvDatabase
pva2pva
pvaClient

Why Environment is Needed

EPICS Modules

- Community Modules  *Full Access*
- Site Specific Modules SLAC, Jefferson Lab, PSI, HZB Helmholtz Zentrum Berlin, SNS Spallation Neutron Source, FRIB, iter *Full & Limited Access*
- Distributed Modules

Email, Private Communication, Sources, Code snippets

EPICS Applications *All Possible Combinations*

For example, Lecroy WaveStation 3000 Series EPICS IOC

Why Environment is Needed

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Front-End (FE)

- Each Site or Person follows the various ways to handle and maintain modules and applications.
- In order to handle this situation, ESS (or each site) needs its own FE system.
- **E3** is the front-end system for users and developers at ESS

FE History at ESS

- CODAC (Iter, maven, RPM based one) : Obsolete
- EEE (PSI Mimic Version) : Outsourcing
- **E3** (based on PSI version) : In-House

EEE/PEE structure : Directory

```
/opt/epics/
├── [iocuser   63] bases
├── [iocuser   16] java
├── [iocuser 8.0K] modules
├── [iocuser   12] require.lock-39d2d0
└── [iocuser   64] require.lock-b316e0
```

```
/opt/epics/bases/
├── [iocuser 4.0K] base-3.14.12.5
├── [iocuser 4.0K] base-3.15.2
└── [iocuser 4.0K] base-3.15.4
```

```
/opt/epics/modules/
├── [iocuser   30] acct
├── [iocuser 4.0K] adandor
├── [iocuser   98] adaravis
├── [iocuser 4.0K] adcore
├── [iocuser   18] adcsimdetector
 ..........................................
├── [iocuser   18] emu-motor
├── [iocuser   30] emu-plc
├── [iocuser 4.0K] environment
 ..................................................
├── [iocuser 4.0K] example
├── [iocuser   18] dataacquisition
├── [iocuser   66] DataAcquisition
 ..............................................................
├── [iocuser   39] wednesday
├── [iocuser   59] wienermpod
├── [iocuser   27] wienermpod-b
├── [iocuser   29] wirescanner
└── [iocuser   18] xml
```

EEE/PEE structure : Directory

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```
/opt/epics/modules/iocStats/
├── [iocuser   54] 3.1.14
│   ├── [iocuser   26] 3.14.12.5
│   ├── [iocuser   26] 3.15.4
│   ├── [iocuser 4.0K] db
│   └── [iocuser 4.0K] opi
└── [iocuser   41] user_name
    ├── [iocuser   26] 3.14.12.5
    ├── [iocuser 4.0K] db
    └── [iocuser 4.0K] opi
```

```
/opt/epics/modules/iocStats/3.1.14/
├── [iocuser   26] 3.14.12.5
│   ├── [iocuser   25] dbd
│   └── [iocuser   27] lib
├── [iocuser   26] 3.15.4
│   ├── [iocuser   25] dbd
│   └── [iocuser   27] lib
│       └── [iocuser   46] centos7-x86_64
├── [iocuser 4.0K] db
│   ├── [iocuser 1.8K] iocAdminRTEMS.substitutions
│   ├── [iocuser 1.2K] iocAdminScanMon.substitutions
│   ├── [iocuser 1.4K] iocAdminSoft.substitutions
│   ├── [iocuser 2.6K] iocAdminVxWorks.substitutions
│   ├── [iocuser 1.1K] iocCluster.template
│   ├── [iocuser  157] iocEnvVar.template
│   ├── [iocuser 1.1K] iocGeneralTime.template
│   ├── [iocuser  632] iocRTEMSOnly.template
│   ├── [iocuser 2.5K] iocRTOS.template
│   ├── [iocuser  555] iocScanMonSum.template
│   ├── [iocuser  639] iocScanMon.template
│   ├── [iocuser 8.5K] ioc.template
│   └── [iocuser  611] iocVxWorksOnly.template
```

EEE/PEE structure : Directory

```
/opt/epics/modules/iocStats/
├── [iocuser   54] 3.1.14
│   ├── [iocuser   26] 3.14.12.5
│   ├── [iocuser   26] 3.15.4
│   ├── [iocuser 4.0K] db
│   └── [iocuser 4.0K] opi
└── [iocuser   41] user_name
    ├── [iocuser   26] 3.14.12.5
    ├── [iocuser 4.0K] db
    └── [iocuser 4.0K] opi
```

```
/opt/epics/modules/iocStats/3.1.14/
├── [iocuser   26] 3.14.12.5
│   ├── [iocuser   25] dbd
│   └── [iocuser   27] lib
├── [iocuser   26] 3.15.4
│   ├── [iocuser   25] dbd
│   └── [iocuser   27] lib
│       └── [iocuser   46] centos7-x86_64
├── [iocuser 4.0K] db
│   ├── [iocuser 1.8K] iocAdminRTEMS.substitutions
│   ├── [iocuser 1.2K] iocAdminScanMon.substitutions
│   ├── [iocuser 1.4K] iocAdminSoft.substitutions
│   ├── [iocuser 2.6K] iocAdminVxWorks.substitutions
│   ├── [iocuser 1.1K] iocCluster.template
│   ├── [iocuser  157] iocEnvVar.template
│   ├── [iocuser 1.1K] iocGeneralTime.template
│   ├── [iocuser  632] iocRTEMSOnly.template
│   ├── [iocuser 2.5K] iocRTOS.template
                       ScanMonSum.template
                       ScanMon.template
                       ioc.template
                       VxWorksOnly.template
```

DB files should be under "base version"
However, it belongs to also iocStats version

E3 : ESS EPICS Environment

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```
/epics/
├── [root    4.0K] base-3.15.5/
└── [root    4.0K] base-3.16.1/
```

E3 : ESS EPICS Environment

EUROPEAN SPALLATION SOURCE

```
/epics/
├── [root    4.0K]  base-3.15.5/
└── [root    4.0K]  base-3.16.1/
```

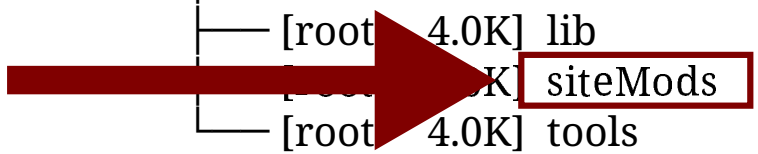
```
base-3.15.5/
├── [root    4.0K]  bin
├── [root    4.0K]  configure
├── [root    4.0K]  db
├── [root    4.0K]  dbd
├── [root    4.0K]  html
├── [root     12K]  include
├── [root    4.0K]  lib
├── [root    4.0K]  require
├── [root    4.0K]  startup
└── [root    4.0K]  templates
```

Require module has the dependency upon EPICS Base, so we put them under each EPICS Base version

E3 : ESS EPICS Environment

Each module has dependency upon a require module version, so we put them under a require version

```
base-3.15.5/require/0.0.1/
├── [root    4.0K]  bin
├── [root    4.0K]  db
├── [root    4.0K]  dbd
├── [root    4.0K]  include
├── [root    4.0K]  lib
├── [root    4.0K]  siteMods
└── [root    4.0K]  tools
```



```
base-3.15.5/
├── [root    4.0K]  bin
├── [root    4.0K]  configure
├── [root    4.0K]  db
├── [root    4.0K]  dbd
├── [root    4.0K]  html
├── [root     12K]  include
├── [root    4.0K]  lib
├── [root    4.0K]  require
├── [root    4.0K]  startup
└── [root    4.0K]  templates
```

```
base-3.15.5/require/
├── [root    4.0K]  0.0.0
├── [root    4.0K]  0.0.1
└── [root    4.0K]  2.5.4
```

E3 : ESS EPICS Environment

EUROPEAN SPALLATION SOURCE

```
base-3.15.5/require/0.0.1/
├── [root     4.0K]  bin
│   ├── [root      20]  ess-env.conf
│   ├── [root     2.3K]  iocsh.bash
│   ├── [root     6.6K]  iocsh_functions
│   └── [root     2.8K]  setE3Env.bash
├── [root     4.0K]  db
│   └── [root      661]  moduleversion.template
├── [root     4.0K]  dbd
│   └── [root      146]  require.dbd
├── [root     4.0K]  include
│   ├── [root      390]  asprintf.h
│   ├── [root      697]  require.h
│   └── [root      177]  strdup.h
├── [root     4.0K]  lib
│   ├── [root     4.0K]  linux-ppc64e6500
│   │   ├── [root      78K]  librequire.so
│   │   └── [root       68]  require.dep
│   └── [root     4.0K]  linux-x86_64
│       ├── [root     141K]  librequire.so
│       └── [root       68]  require.dep
├── [root     4.0K]  siteMods
│   └── [root     4.0K]  iocStats
│       ├── [root     4.0K]  0.0.1
│       └── [root     4.0K]  develop
└── [root     4.0K]  tools
    ├── [jhlee     38K]  driver.makefile
    ├── [root     3.2K]  expandDBD.tcl
    └── [root     7.9K]  getVersion.tcl
```

iocsh.bash
setE3Env.bash
per a version of require

makefile, and other scripts
per a version of require

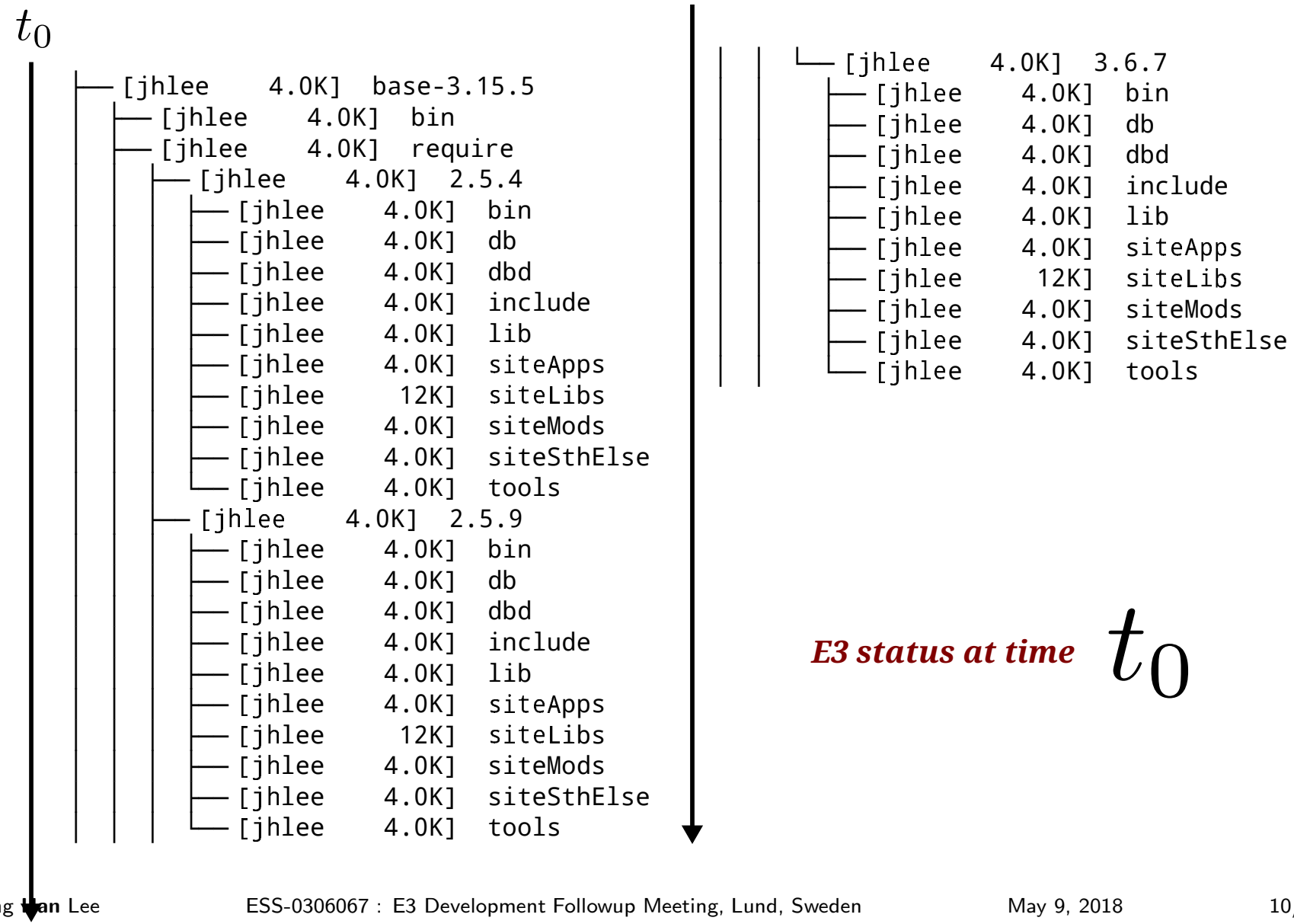
E3 : ESS EPICS Environment

```
base-3.15.5/require/0.0.1/siteMods/
└── [root     4.0K]  iocStats
    ├── [root     4.0K]  0.0.1
    │   ├── [root     4.0K]  db
    │   ├── [root     4.0K]  dbd
    │   ├── [root     4.0K]  include
    │   └── [root     4.0K]  lib
    └── [root     4.0K]  develop
        ├── [root     4.0K]  db
        ├── [root     4.0K]  dbd
        ├── [root     4.0K]  include
        └── [root     4.0K]  lib
```

DB files belong to its version

```
base-3.15.5/require/0.0.1/siteMods/iocStats/0.0.1/
├── [root     4.0K]  db
│   ├── [root      2.0K]  access.db
│   ├── [root      1.1K]  iocCluster.template
│   ├── [root       157]  iocEnvVar.template
│   ├── [root      1.1K]  iocGeneralTime.template
│   ├── [root       632]  iocRTEMSOnly.template
│   ├── [root      2.5K]  iocRTOS.template
│   ├── [root       555]  iocScanMonSum.template
│   ├── [root       639]  iocScanMon.template
│   ├── [root      8.5K]  ioc.template
│   └── [root       611]  iocVxWorksOnly.template
├── [root     4.0K]  dbd
│   └── [root       418]  iocStats.dbd
├── [root     4.0K]  include
│   ├── [root      3.4K]  devIocStats.h
│   └── [root       946]  devIocStatsOSD.h
└── [root     4.0K]  lib
    ├── [root     4.0K]  linux-ppc64e6500
    │   ├── [root       31]  iocStats.dep
    │   └── [root      69K]  libiocStats.so
    └── [root     4.0K]  linux-x86_64
        ├── [root       31]  iocStats.dep
        └── [root     151K]  libiocStats.so
```

E3 : From t_0 to t_1



E3 status at time t_0

E3 : From t_0 to t_1

t_0

```
├── [jhlee    4.0K]  base-3.15.5
│   ├── [jhlee    4.0K]  bin
│   ├── [jhlee    4.0K]  require
```

E3 Status at time t_1

We can drop old require versions in base-3.15.5, that means all old modules below them also we can drop.

Or, we can seperate old E3 easily, in case we can use only them to run old IOC, if the ioc has no issue with limited network and disk resources.

```
│   │   └── [jhlee    4.0K]  3.6.7
│   │       ├── [jhlee    4.0K]  bin
│   │       ├── [jhlee    4.0K]  db
│   │       ├── [jhlee    4.0K]  dbd
│   │       ├── [jhlee    4.0K]  include
│   │       ├── [jhlee    4.0K]  lib
│   │       ├── [jhlee    4.0K]  siteApps
│   │       ├── [jhlee     12K]  siteLibs
│   │       ├── [jhlee    4.0K]  siteMods
│   │       ├── [jhlee    4.0K]  siteSthElse
│   │       └── [jhlee    4.0K]  tools
├── [jhlee    4.0K]  base-3.16.1
│   ├── [jhlee    4.0K]  bin
│   ├── [jhlee    4.0K]  require
│   │   ├── [jhlee    4.0K]  2.5.9
│   │   ├── [jhlee    4.0K]  3.6.7
│   │   └── [jhlee    4.0K]  3.6.8
├── [jhlee    4.0K]  base-7.0.0
│   ├── [jhlee    4.0K]  bin
│   ├── [jhlee    4.0K]  require
│   │   ├── [jhlee    4.0K]  3.6.7
│   │   ├── [jhlee    4.0K]  4.0.0
│   │   └── [jhlee    4.0K]  5.0.0
```

t_1

Warning ..

The following few pages are not 100% correct, but partly correct.
However with many assumptions and ignorance on different technical aspects, I would like to show the complicated situations which we will see in the near future.
And I would like to show how significantly we can reduce its complexity with the current E3 system.

Han

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Case 2 : Base (μ), Require (ν), N Module (ρ)

- Assumption 1 : all versions (μ, ν, ρ, i) are compatible with each others
- Assumption 2 : $N = 3$, we have 3 different modules
- Assumption 3 : For 2 years, we have 2 base version ($\mu = 2$), 4 requires ($\nu = 4$), and 6 module version ($\rho, \sigma, \delta = 6$) per each modules
- $\mathrm{IOC}_{\mu\nu\rho\sigma\delta} = \mathrm{B}_\mu \times \mathrm{R}_\nu \times \mathrm{M}_\rho^1 \times \mathrm{M}_\sigma^2 \times \mathrm{M}_\delta^3$
- The total number of the likely existent IOC in our EPICS environment:

$$\sum_{\mu=1}^{2}\sum_{\nu=1}^{4}\sum_{\rho=1}^{6}\sum_{\sigma=1}^{6}\sum_{\delta=1}^{6}\mathrm{IOC}_{\mu\nu\rho\sigma\delta} = \mathbf{1782}$$

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Case 2 : Base (μ), Require (ν), N Module (ρ)

- Assumption 1 : all versions (μ, ν, ρ, i) are compatible with each others
- Assumption 2 : $N = 3$, we have 3 different modules
- **What about 2+ years later?**
- $\mathrm{IOC}_{\mu\nu\rho\sigma\delta} = \mathrm{B}_\mu \times \mathrm{R}_\nu \times \mathrm{M}_\rho^1 \times \mathrm{M}_\sigma^2 \times \mathrm{M}_\delta^3$
- The total number of the likely existent IOC in our EPICS environment:

$$\sum_{\mu=1}^{2} \sum_{\nu=1}^{4} \sum_{\rho=1}^{6} \sum_{\sigma=1}^{6} \sum_{\delta=1}^{6} \mathrm{IOC}_{\mu\nu\rho\sigma\delta} = \mathbf{1782}$$

EUROPEAN SPALLATION SOURCE

Case 2 : Base (μ), Require (ν), N Module (ρ)

- Assumption 1 : all versions (μ, ν, ρ, i) are compatible with each others
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- **What about 2+ years later?**
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- The total number of the likely existent IOC in our EPICS environment:

$$\sum_{\mu=1}^{2}\sum_{\nu=1}^{4}\sum_{\rho=1}^{6}\sum_{\sigma=1}^{6}\sum_{\delta=1}^{6}\mathrm{IOC}_{\mu\nu\rho\sigma\delta} = \mathbf{1782}$$

- Are we sure how to handle them in terms of disk space, network traffic, and so on?
- How can we drop old base, require, and module versions, which no one uses?
- The assumption 1 likely is not true, we have a lot of incompatible issues among all of them. How do we fix this?

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Case 2 : Base (μ), Require (ν), N Module (ρ)

- Assumption 1 : all versions (μ, ν, ρ, i) are compatible with each others
- Assumption 2 : $N = 3$, we have 3 different modules
- Assumption 3 : For 2 years, we have 2 base version ($\mu = 2$), 4 requires ($\nu = 4$), and 6 module version ($\rho, \sigma, \delta = 6$) per each modules
- $\mathrm{IOC}_{11\rho\sigma\delta} = \mathrm{B}_1 \times \mathrm{R}_1 \times \mathrm{M}_\rho^1 \times \mathrm{M}_\sigma^2 \times \mathrm{M}_\delta^3$
- The total number of the likely existent IOC in our EPICS environment:

$$\sum_{\rho=1}^{6} \sum_{\sigma=1}^{6} \sum_{\delta=1}^{6} \mathrm{IOC}_{11\rho\sigma\delta} = \mathbf{216}$$

E3 Stages

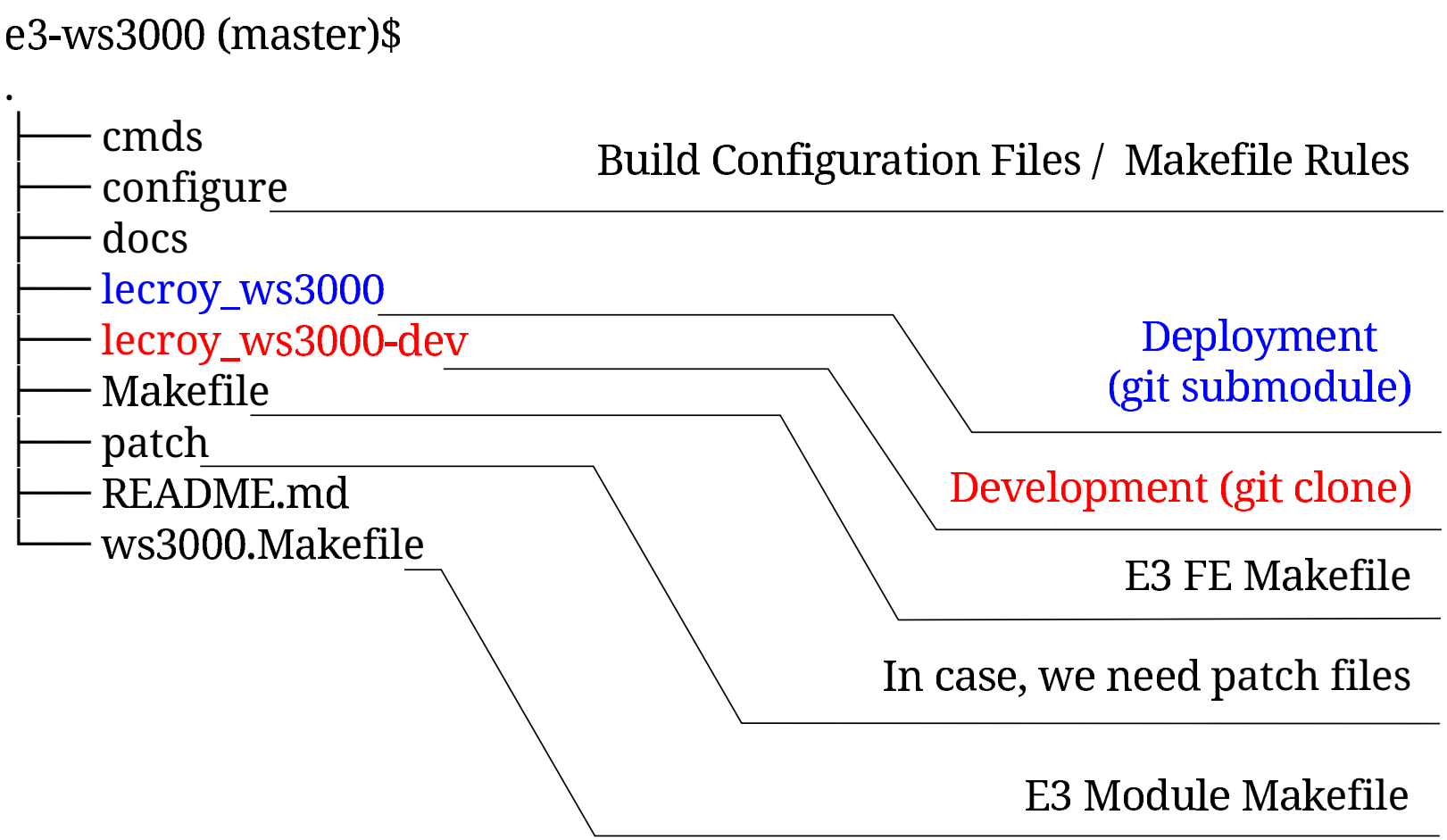
Stage 2 : E3

- Redesigned the Building System (similar approach to EPICS Building System)
- Heavily modified PSI makefile, Replaced iocsh shell.
- Integration Test in progress
- Target Due Date in production : early August, 2018

Stage 3 : E3+

- We can use the EPICS building system instead of the modified PSI makefile
- Completely replace the PSI require module.
- Collect possible technical resources, design, and discuss its requirements
- Target Due Date : mid, 2020

A Real Example E3 FE Structure for Lecroy WaveStation EPICS IOC



Short Introduction of E3 FE Template Generator

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Complicate?

```
$ ./create_e3_modules.bash -m modules_conf/adpico8.conf
```

adpico8.conf
EPICS_MODULE_NAME:=adpico8
EPICS_MODULE_URL:=https://github.com/hinxx
E3_TARGET_URL:=https://github.com/icshwi
E3_MODULE_SRC_PATH:=adpico8

```
require ws3000,0.0.1
require iocStats,1856ef5
require autosave,5.9.0
require mrfioc2,2.2.0-rc1

epicsEnvSet("IOC","SUPERCYCLE")
epicsEnvSet("TOP",".")
epicsEnvSet(P, "usbtmc")
epicsEnvSet(R, "icslab")
epicsEnvSet(USBTMCPORT, "usbtmc0")
epicsEnvSet(WS3122PORT, "WS3122" )
epicsEnvSet(vendorNum,  "05ff")
epicsEnvSet(productNum, "0a21")
epicsEnvSet("EPICS_CA_MAX_ARRAY_BYTES","10000000")
epicsEnvSet("DEV1", "WSEVR")
epicsEnvSet("MainEvtCODE" "14")
epicsEnvSet("HeartBeatEvtCODE"   "122")
epicsEnvSet("ESSEvtClockRate"  "88.0525")

usbtmcConfigure("$(USBTMCPORT)", "0x$(vendorNum)", "0x$(productNum)")
drvWS3122Configure("$(WS3122PORT)", "$(USBTMCPORT)")
mrmEvrSetupPCI("$(DEV1)",  "01:00.0")

dbLoadRecords("asynRecord.db", "P=$(P), R=$(R),  PORT=$(USBTMCPORT), ADDR=0, OMAX=100,IMAX=100")
dbLoadRecords("WS3122Base.db", "P=$(P):,R=$(R):, PORT=$(WS3122PORT)")
dbLoadRecords("BasicWave.db",  "P=$(P):,R=$(R):, PORT=$(WS3122PORT)")
dbLoadRecords("BurstWave.db",  "P=$(P):,R=$(R):, PORT=$(WS3122PORT)")
dbLoadRecords("WS3122Cmds.db", "P=$(P):,R=$(R):, PORT=$(WS3122PORT)")
dbLoadRecords("iocAdminSoft.db", "IOC=$(P):$(R):IocStats")
dbLoadRecords("evr-pcie-300dc-ess.db","EVR=$(DEV1), SYS=$(IOC), D=$(DEV1), FEVT=$(ESSEvtClockRate)")

var evrMrmTimeNSOverflowThreshold 100000

< ${TOP}/save_restore_before_init.cmd
iocInit
< ${TOP}/save_restore_after_init.cmd

dbl > "${TOP}/${IOC}_PVs.list"

dbpf $(IOC)-$(DEV1):DlyGen0-Evt-Trig0-SP $(MainEvtCODE)
dbpf $(IOC)-$(DEV1):DlyGen0-Width-SP 1000 # time in us
dbpf $(IOC)-$(DEV1):OutFPUV02-Src-SP 0 # trigger from delay generator 0
dbpf $(IOC)-$(DEV1):OutFPUV03-Src-SP 0 # trigger from delay generator 0
```

$ iocsh.bash e3_ws3000_evr.cmd

The system is running
at ICS Tuna Lab
for the SuperCycle Test

Deployment Mode vs Development on E3

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Type	Deployment	Development
Configuration	RELEASE CONFIG_MODULE	RELEASE_DEV CONFIG_MODULE_DEV
Build Commands	make init make build make install make env make uninstall make rebuild	make devinit make devbuild make devinstall make devenv make devuninstall make devrebuild

What's New on E3

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- Rewrite iocsh.bash completely
- Dynamic env. setting per a Require version
- More than 50 modules were integrated into E3 (Timing System, IFC platforms, Motion, Area Detector, EPICS Common modules)

What's New on E3

NO **MORE** Largest Module Version will be used when Building and Loading. For example, in the case that MODULE A (**MA**) with the version `MA2.0` needs MODULE B (**MB**). And we need to compile **MA**.

Building : Header Files

case 1 If the VERSION of **MB** with `MB1.0` is defined, it will be used to compile **MA**.

case 2 if not, it will use the latest (e.g., `1.2.3`) version to compile **MA**.

Loading : Library Files

case 1 **MB** with `MB1.0` will be loaded when `require` **MA**,`MA2.0`

case 2 **MB** with `1.2.3` will be loaded when `require` **MA**,`MA2.0`

Failure Scenario : Still, but Less and Less

- Very small probability p_μ[2]on IOC CRASH of a module (so called Han) while loading if Han has more than one dependent module and the dependent modules have also dependencies.
- Failure Rate $= \prod_{\mu=1}^{n} p_\mu$, where n is the number of dependent modules, which have its own dependencies.
- Main reason is that two independent methods to select *A VERSION* exist in **Building** and LOADING
- However, we can minimize that scenario with the restrict Release and Change plans.

[2]Actual number cannot be estimated because it comes from human behavior

Let us Check what we build ...

- `bash e3.bash -g jhlee load`
- `bash e3.bash -g jhlee env`
- `source /epics/base-3.15.5/require/3.0.0/bin/setE3Env.bash`
- `iocsh.bash cmds/20180509.cmd "TOP=cmds"`
- `bash cmds/watch_e3.sh`

Clone and Subscribe It Today!

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```
$ git clone https://github.com/icshwi/e3
```

Tested Linux Distributions

- CentOS 7.4
- Debian 8/9
- Ubuntu 16/17
- LinuxMint 18
- Fedora 27
- Raspbian Stretch

Mailing address

- `e3-tech-talk@esss.se` : for anyone, OPEN
- `e3-core-talk@esss.se` : for core developers, CLOSE

Outlook

Near Future ...

- Motion related EPICS modules Test in next week
- Area Detector (ADPointGrey) Test in next week
- Limited BCM in ICS Tuna Lab Test in next-to-next week
- LLRF Integration is on-going.

Chess Number : ESS-0306067

Questions?

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Much to learn you still have ... my old padawan. This is just the beginning!

Yoda

Tack!

감사합니다!

Thank you!

Dankeschön!

¡Gracias!

Grazie!

Merci!

Kiitos!

☺