TwinCAT BSD Virtual Machines and Ansible Provisioning

Ken Lauer [1] – klauer@slac.stanford.edu

1. SLAC National Accelerator Laboratory, USA

TWINCAT?

TwinCAT is the Beckhoff solution that turns standard PC hardware into a PLC (Programmable Logic Controller). TwinCAT/BSD (TcBSD) is a lightweight FreeBSD-based operating system that Beckhoff has offered since 2021 as an alternative to Microsoft Windows. These BSD-based PLCs offer the same runtime capabilities as their Windows-based counterparts and bring the benefits of a Unix-like operating system.

The MEC-U (Matter in Extreme Conditions Upgrade) project at LCLS-II will use TwinCAT/BSD PLCs exclusively as part of its standard platform.

ANSIBLE PROVISIONING

Ansible playbooks make provisioning Tc/BSD VMs and real PLCs simple. Automated installations of TwinCAT tools and packages, upgrades of runtime versions, route management, AMS Net ID settings, firewall configuration, and more are now handled with ease when using TwinCAT/BSD with Ansible. A test repository [1] offers a sample of how to do this.

NICETIES

Our example playbook provides the option for:

- Bootstrapping to install required Ansible dependencies
- A customized bash prompt to show the system state (config mode vs run mode)
- Installs user-specified required libraries
- Adds, modifies, or removes ADS routes on a PLC
- Configures the firewall to let ADS traffic through
- Customizes other settings such as heap memory size and locked memory size

EPICS?

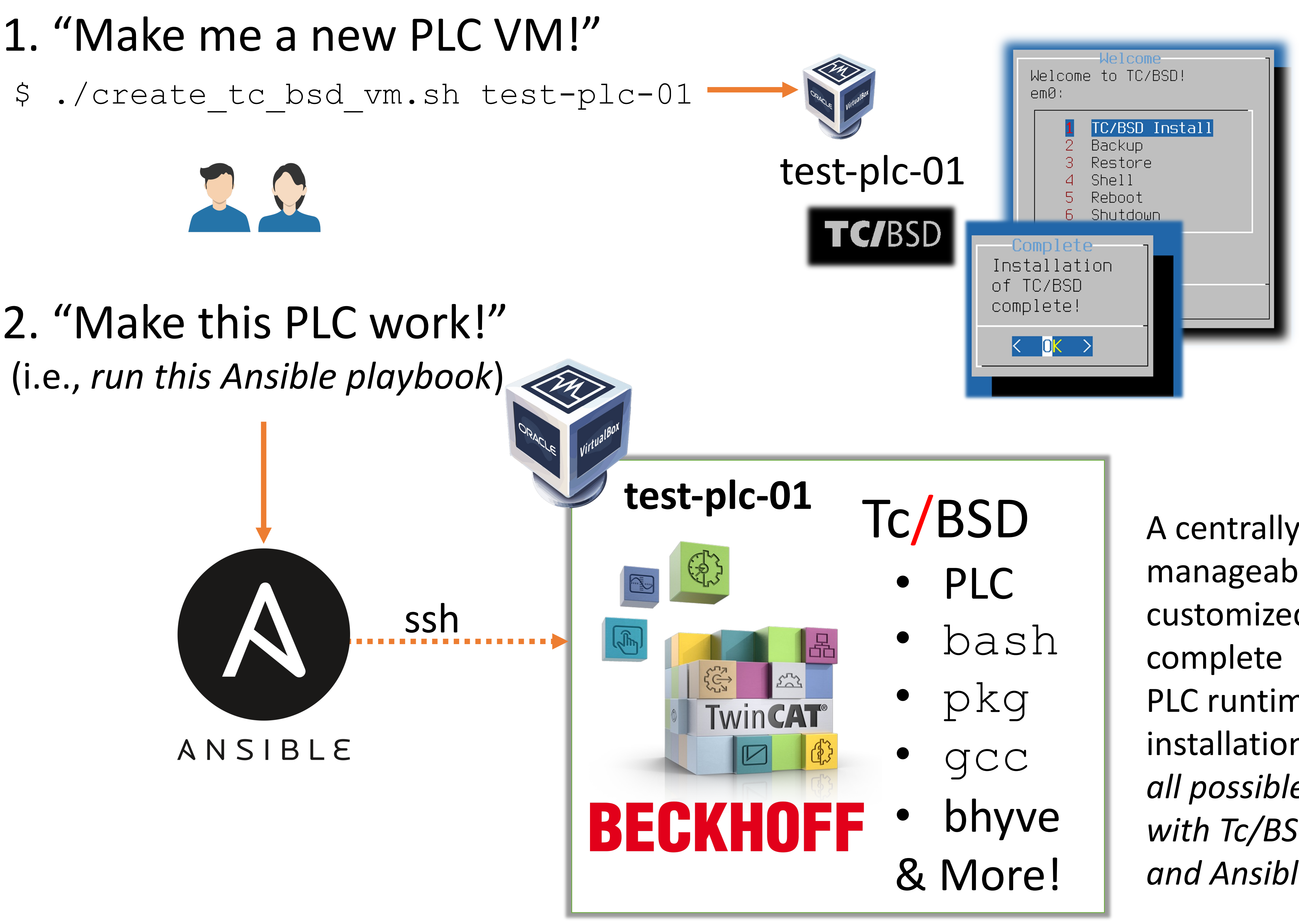
At the LCLS, we have dozens of TwinCAT PLCs with auto-generated EPICS IOCs running on separate Linux hosts.

With TC/BSD, we can now compile and run EPICS on PLCs. Alternatively, LinuxEmu as part of FreeBSD itself runs unmodified, statically-linked RHEL7-x86_64 binaries as-is.

Running IOCs directly on the PLC could improve performance, remove any possibility of IOC database desynchronization to PLC projects and synchronize the state of the IOC with that of the TwinCAT runtime.

BENEFITS

- TwinCAT/BSD hosts can be accessed by way of SSH, making centralized management a snap. Bash, Python, and other familiar command-line tools are readily available.
- TwinCAT library upgrades are as easy as working with the supplied package manager.
- Operating system upgrades can also be performed in-place and remotely.
- VMs *on the PLC* are even possible with bhyve.
- Development tools can be used natively.



1. "Make me a new PLC VM!"

```
$ ./create_tc_bsd_vm.sh test-plc-01
```

```
Welcome
Welcome to TC/BSD!
em0:

 1  TC/BSD Install
 2  Backup
 3  Restore
 4  Shell
 5  Reboot
 6  Shutdown
```

```
Complete
Installation
of TC/BSD
complete!

<  OK  >
```

2. "Make this PLC work!"
(i.e., *run this Ansible playbook*)

Tc/BSD
- PLC
- bash
- pkg
- gcc
- bhyve

& More!

A centrally-manageable, customized, complete PLC runtime installation: *all possible with Tc/BSD and Ansible.*

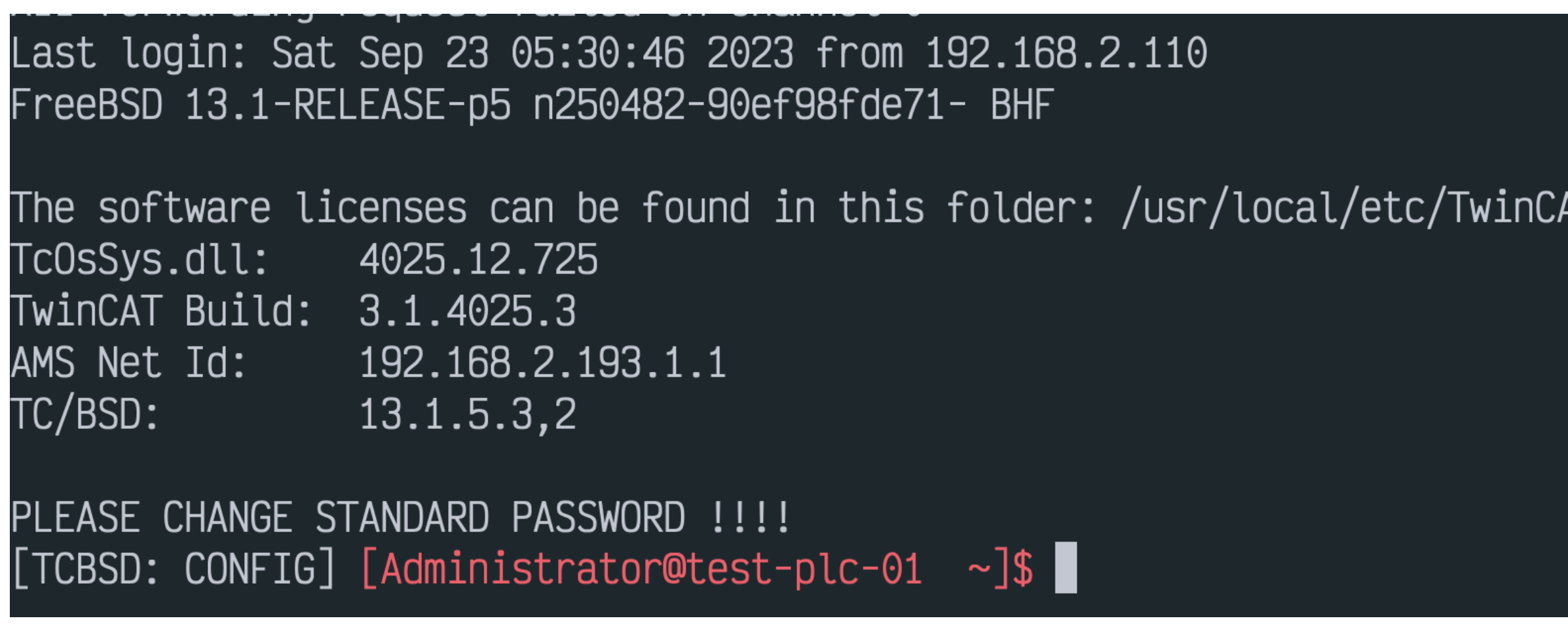
FUTURE

Tc/BSD deployments are in the testing phase at the LCLS. In the future, we may:

- Centrally manage all PLCs with Ansible and integrate it alongside our IT team (along with well-defined roles and such).
- Investigate a path forward for EPICS + ADS over localhost is top on our list.
- Deploy PLC projects from Ansible (outside of Visual Studio)
- Deploy multiple VMs for development and testing may be considered.

A REAL SHELL!

Tc/BSD PLCs offer a real shell to manage your PLC. We have installed bash and provided an example customized bash prompt to show the system state: config mode vs run mode.

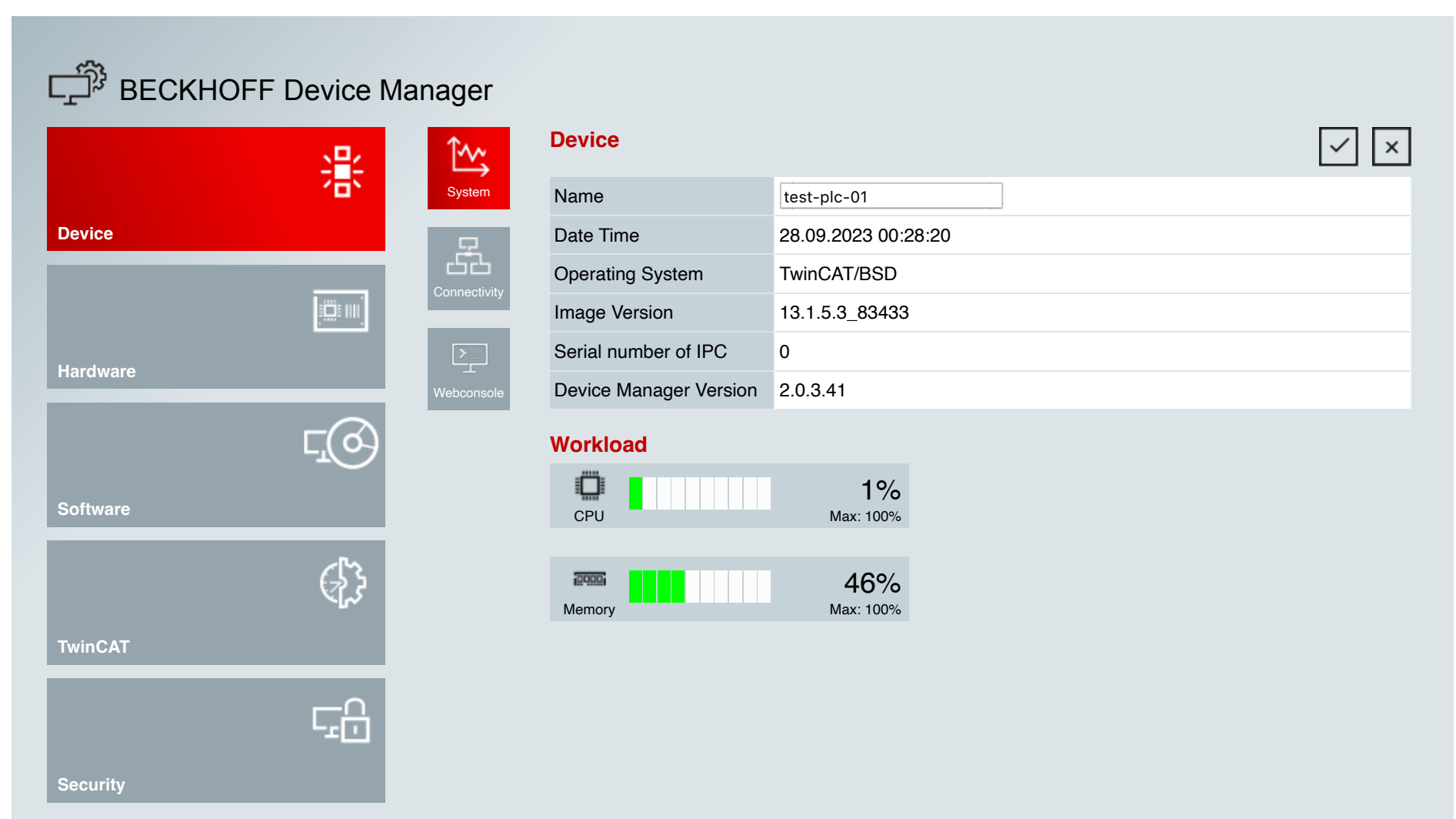


```
Last login: Sat Sep 23 05:30:46 2023 from 192.168.2.110
FreeBSD 13.1-RELEASE-p5 n250482-90ef98fde71- BHF

The software licenses can be found in this folder: /usr/local/etc/TwinCA
TcOsSys.dll:     4025.12.725
TwinCAT Build:   3.1.4025.3
AMS Net Id:      192.168.2.193.1.1
TC/BSD:          13.1.5.3,2

PLEASE CHANGE STANDARD PASSWORD !!!!
[TCBSD: CONFIG] [Administrator@test-plc-01  ~]$
```

A COMPLETE TWINCAT RUNTIME ON TC/BSD



Device

Name: test-plc-01
Date Time: 28.09.2023 00:28:20
Operating System: TwinCAT/BSD
Image Version: 13.1.5.3_83433
Serial number of IPC: 0
Device Manager Version: 2.0.3.41

Workload

CPU 1% Max: 100%
Memory 46% Max: 100%

ACKNOWLEDGMENTS

SLAC National Accelerator Laboratory is operated by Stanford University for the U.S. Department of Energy Office of Science. Work supported by U.S. D.O.E. Contract DE-AC02-76SF00515

MEC-U is supported by the U.S. Department of Energy,
Office of Science, Office of Fusion Energy Sciences under Contract No. DE-AC02-76SF00515.

1. The Ansible playbooks, configuration, and notes:
https://github.com/pcdshub/twincat-bsd-ansible
2. TwinCAT/BSD
https://www.beckhoff.com/en-us/products/ipc/software-and-tools/twincat-bsd/
3. Tc/BSD packages (using Tc/BSD 13 stable + FreeBSD 13 currently)
https://tcbsd.beckhoff.com/TCBSD/13/testing/packages/packagesite.html