

FreeBSD as the backbone of a vaccine/medication refrigerator monitoring system

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Introduction

- Dr. Phillip J. Vuchetich is president of Arxsine, Inc., a Nebraska, USA based Pharmacy Informatics and healthcare analytics company. Over 25 years experience in teaching, research, and consulting in academia, government, large health system, and community pharmacy.
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Agenda

Regulatory Environment

Project Overview

Architecture

FreeBSD

Regulatory Environment

US Federal

- Food and Drug Administration
- Centers for Disease Control and Prevention

US States

- Statutes and Regulations

NGOs

- The Joint Commission (accreditation)
- United States Pharmacopoeia (standards)
- NSF/ANSI (standard 456 - 2021a)

Temperature Ranges

Controlled Room Temp: 20 — 25 °C (68 — 77 °F)

Cool: 8 — 15 °C (46 — 59 °F)

Refrigerator: 2 — 8 °C (36 — 46 °F)

Freezer: -25 — -10 °C (-13 — +14 °F)

ULT Freezer -90 — -60 °C (-130 — -76 °F)

Accuracy +/- 0.5 °C, or +/- 1 °F or better

USP chapter 1079 reference ranges. Not exact conversion between units.

Project Overview

IOT device

Networking

Data logging

Alerting

Architecture

IOT device

- Zephyr RTOS
- Nordic Semiconductor nrf9160 MCU (ARM Cortex M-33)
- Environmental sensors (Temperature, Humidity)
- Battery backup

Network connectivity

- Cellular CAT-M1
- IPv4/IPv6 dual stack

Architecture

Monitoring

- MQTT (nrfCloud, Mosquitto)
- Digital datalog (PostgreSQL)

Alerting

- Network monitoring system
- email
- SMS
- APIs to send message any other system

Why FreeBSD?

Server OS Requirements

- Long term maintainability
- Documentation
- Stability
- Network Security
- Deployment options

FreeBSD Kernel + Userland

Long term maintainability

- 14.0-RELEASE series support for 5 years

Simple update and upgrade between versions

```
# freebsd-update fetch  
# freebsd-update install  
# freebsd-update -r 14.1-RELEASE upgrade
```

Documentation updated with version updates

Principle Of Least Astonishment

FreeBSD Features

ports

ZFS

Jails

pf

DTrace

mtree

FreeBSD ports

Ports

```
# make config ->  
PGSQL=on
```

Porters Handbook

```
FLAVORS = default custom  
OPTIONS = PGSQL
```

Poudriere

Enable pre-compiled versions for distribution

```
/usr/local/etc/pkg/repos/FreeBSD.conf  
custom: {  
  url: "http://pkg.example.com/repository",  
  enabled: yes,  
}
```

FreeBSD OpenZFS

RAID without hardware

```
# zpool-create tank mirror sda sdb spare sdc
```

Integrated Backup and recovery

```
# zfs-snapshot tank@2024-05-31-1500  
# zfs-send tank@2024-05-31-1500 | ssh host zfs-receive...
```

Tune dataset for PostgreSQL

```
# zfs set recordsize=8K tank/jails/pg16/data  
PostgreSQL full_page_writes=off
```

Nearly free compression

```
# zfs set compression=on tank
```

Adaptive Replacement Cache / L2ARC

- Balance RAM, SSD, spinning drive

FreeBSD Jails

Built in with base system + userland tools

optional manager applications

Separation of components

database, monitoring application, ETL, website UI

ability to scale/migrate each application

cpuset(1), rctl(8)
zfs send | recv

Ability to add applications

separate jail for each application or customer

OpenBSD pf

Readable config

Well documented

Easy routing to jails

```
rdr pass on $ext_if proto tcp from any to $ext_if port https -> 127.0.1.3
```

FreeBSD DTrace

Currently using for learning internals

- Performance bottlenecks

Will use for optimization

- When host utilization increases

PostgreSQL already has Dtrace available (build option)

- Several presentations, blog posts to read first

FreeBSD mtree

Work in Progress

Goals:

1. Be able to verify which config files differ from model
2. Verify system binaries (IDS)

mtree