

# Linux on Mainframes

—

Past, present and future



**Elizabeth K. Joseph**

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July 3, 2019

Philadelphia area Linux Users Group

# Elizabeth K. Joseph

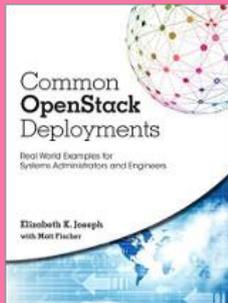
Developer Advocate, IBM Z

(I talk to techies, I don't know how to sell you a mainframe 🙄)

Debian / Ubuntu



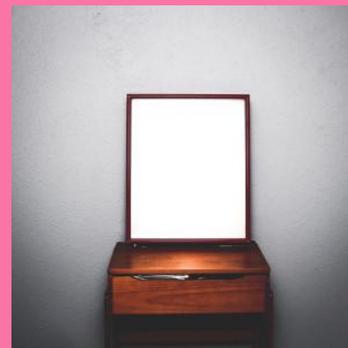
OpenStack



Apache Mesos

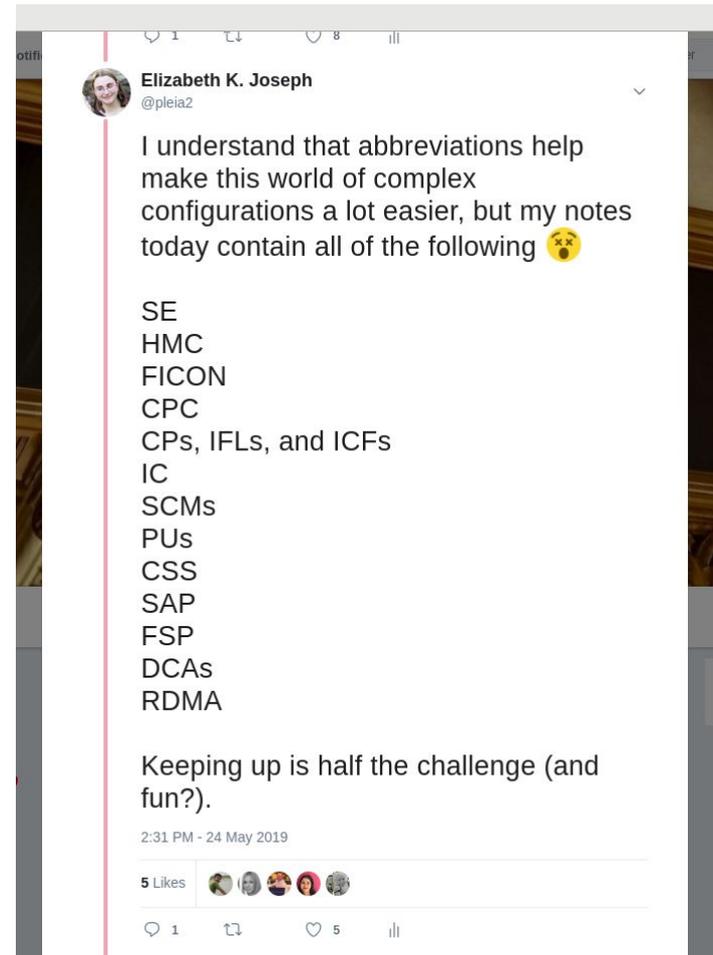


Linux on Z



⚠️ !!!Warning!!! ⚠️

Abbreviation Soup  
Ahead



# What is a mainframe?

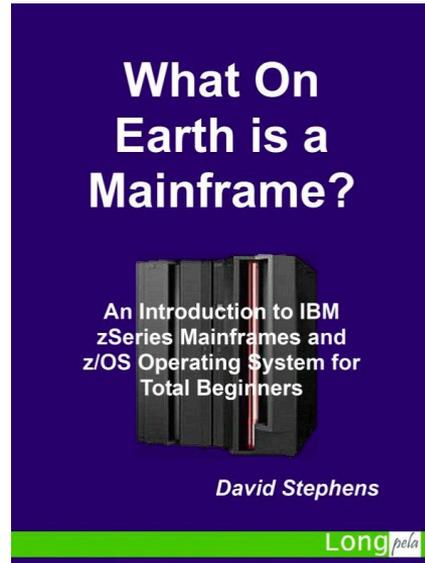
*Depends on who you ask.*

Traditionally runs z/OS, but increasingly Linux too.

Data, data, data.

Batch processing!

Enterprise-grade hardware  
and storage.

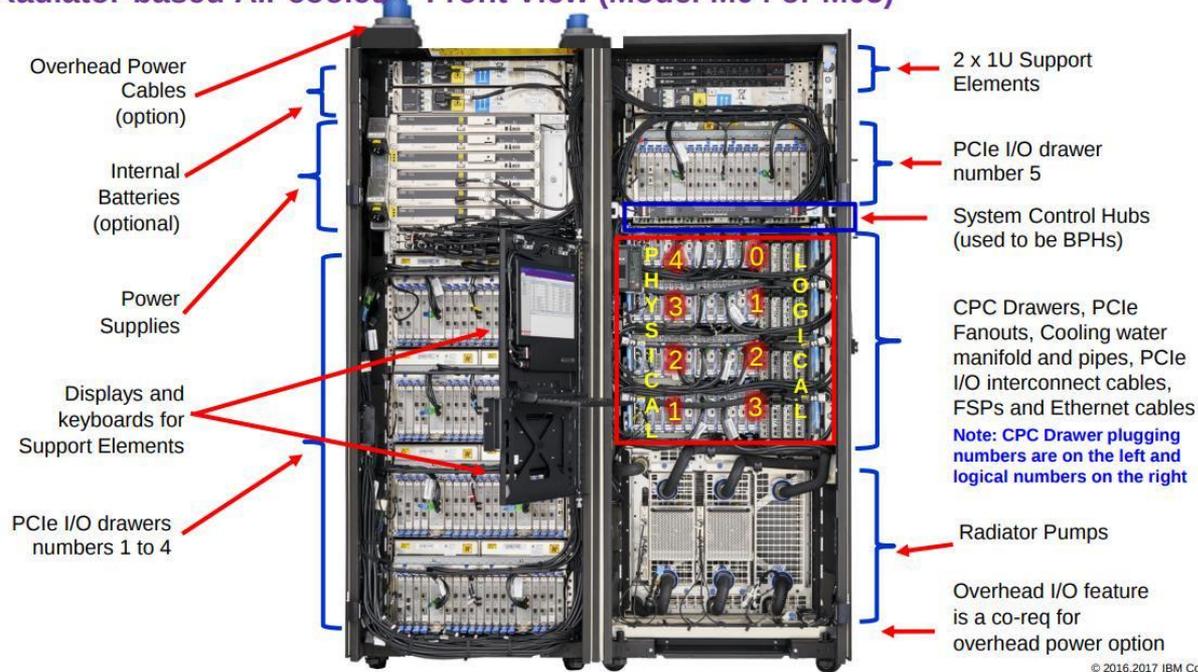


# What is a mainframe?

IBM Z

IBM

## z14 Radiator-based Air cooled – Front View (Model M04 or M05)



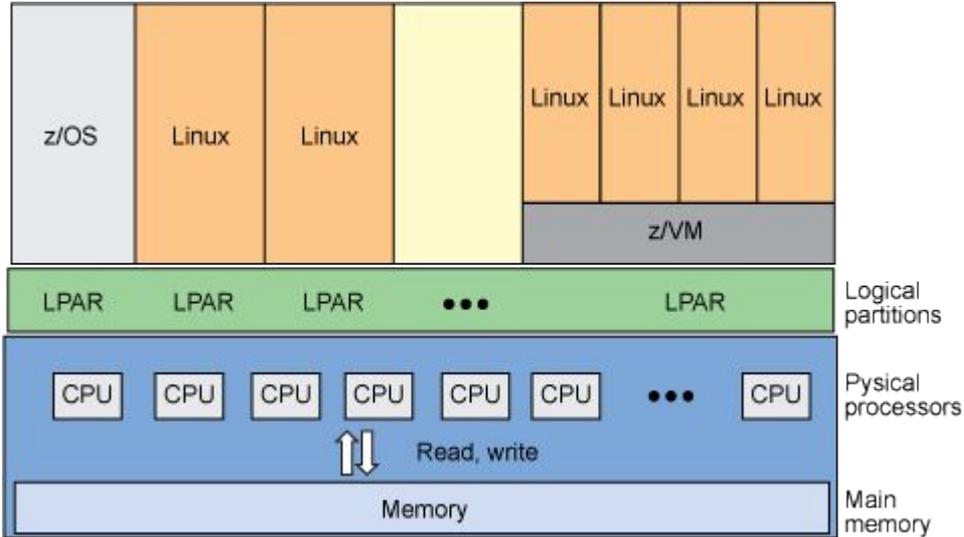
IBM Z TLLB15

© 2016,2017 IBM Corporation

Source:

<https://www.ibm.com/developerworks/community/wikis/form/anonymous/api/wiki/33d270cb-c060-40f6-99f3-956c3cb452a3/page/885fd4df-c77d-4bb8-a43b-f4f44100b3ac/attachment/7fd7adad-44dd-43c9-90d7-5c97650da544/media/IBM%20z14%20technology%20Pitch.pdf>

# How it works with Linux



There is always some kind of virtualization being used for Linux on Z.

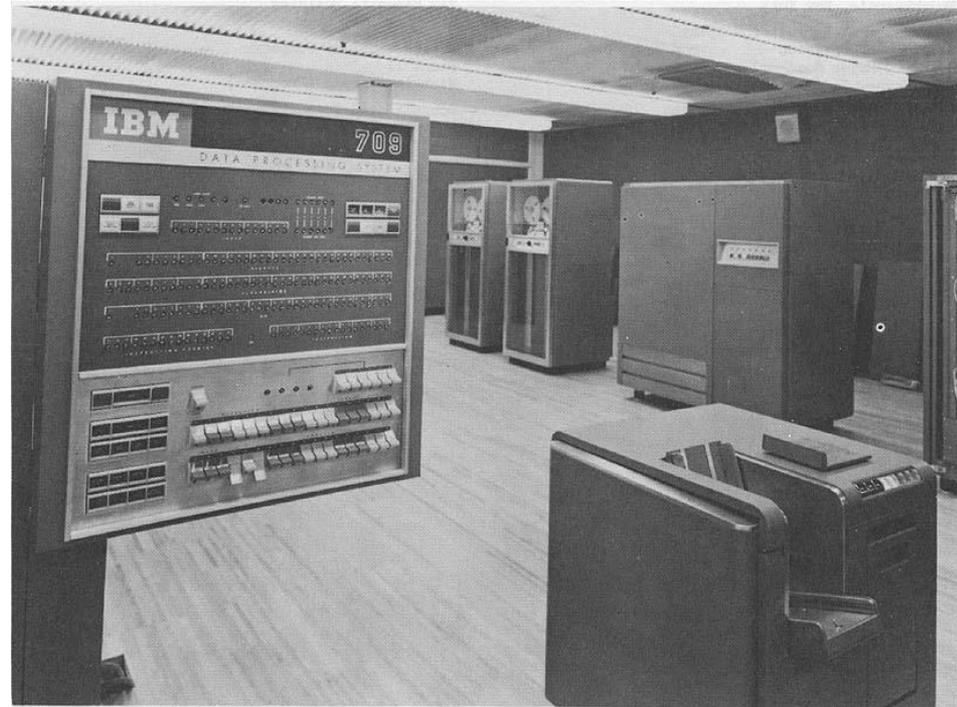
Using z/VM (or KVM!), one or more Linux installs can be put on a single Logical Partition (LPAR).

Using Processor Resource and System Manager (PR/SM) a single Linux instance can be installed on a single LPAR.

Image source: <https://www.ibm.com/developerworks/library/l-systemz/>

Once upon a time  
mainframes lacked  
time-sharing

Papers discussing time-sharing  
were published as early as  
1959, but Compatible  
Time-Sharing System (CTSS) was  
first demoed by MIT on an IBM  
709 in 1961.



Several iterations later... VM/370, in 1972

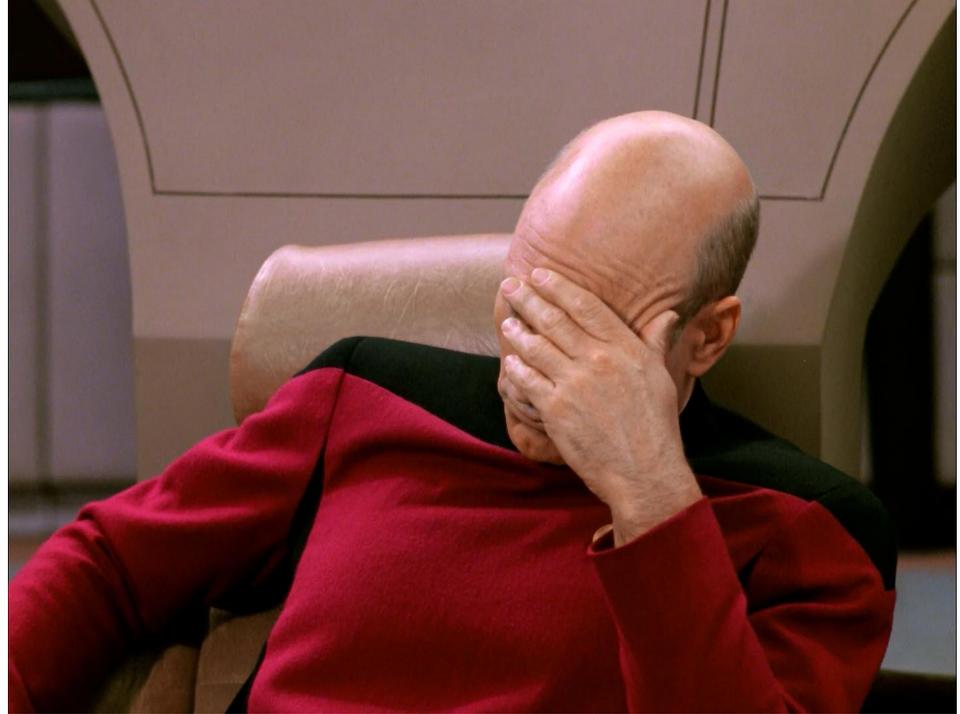


Want to know about all those iterations? Melinda Varian has published a fascinating history, available in several formats, on her website: <http://www.leeandmelindavarian.com/Melinda/>

IBM: **“I don't think  
anyone needs VMs”**

(paraphrased)

The Doubtful Decade.



# But it got better

The Doubtful Decade ended and VM community thrived, along with the technology and support from IBM.

In 1994 experimental TCP/IP support was added to VM, adding a key component to supporting Linux 5 years later.

# Linux Origins: Bigfoot

Developed by Linus Vepstas in 1998-1999 as a community effort.

“the **Bigfoot (i370)** port was started first, but is currently stagnant for essentially political, social, and market reasons.”

Source: Linus Vepsta's site on Linux on s390

<https://linas.org/linux/i370.html>

# Why did the community want it?

“Why? Good question. One we've asked ourselves many times. Why do you do the things you do? If you think about it, you can probably find a hundred rationalizations for what your gut makes you to do. Here's some of ours:

- Stunt
- To Learn
- Because Its There
- Because Its Knarly, Duude!
- I/O
- Address Spaces and Access Lists
- VM
- The Business Model”

Source: <https://linas.org/linux/i370-why.html>

# Linux Origins: Linux for S/390

**Linux for S/390** began when “IBM published a collection of patches and additions to the Linux 2.2.13 kernel on December 18, 1999, to start today's mainline Linux on Z. Formal product announcements quickly followed in 2000”

Marist File System was the first Linux distro put together out of Marist College in Poughkeepsie, NY. Think Blue Linux by Millenux in Germany was an early distro with Red Hat packages and the IBM kernel for mainframes. Other commercial editions quickly followed.

Source: [https://en.wikipedia.org/wiki/Linux\\_on\\_z\\_Systems](https://en.wikipedia.org/wiki/Linux_on_z_Systems)

This is the current, actively developed iteration that all the major platforms are part of today.

Why did IBM want it?



IBM "Heist" commercial, 2001 <https://www.youtube.com/watch?v=uxg17JlyFas>

your email

Linux

## S/390: The Linux Dream Machine

### Linux Everywhere: More than a Slogan

Scott Courtney

Wednesday, February 23, 2000 09:19:48 AM

Let's play a word association game, shall we? The first word is "mainframe."

Many Linux enthusiasts were born and bred in an era of PCs that are already fast and even administrators of large-scale servers are reluctant to spend seven figures on Big "mainframe," there's a good chance that some of the words that came to mind were:

## ComputerWorld (Denmark): Linux on IBM S/390 mainframe

Oct 12, 1999, 01:52 UTC (19 Talkbacks) (Other stories by [J.O.S. Svendsen](#))

[ *Linux Today* reader [Hans Schou](#) writes: ]

"Friday 8 october 1999 there was a story in the Danish Computerworld about IBM had ported Linux to the S/390 mainframe.

For some people this would not be amazing, as there was a posting to the Linux Kernel list back in march 1999, where a guy asked about DMA buffers and address space. The posting came from 3dlabs.com and the rumor began that IBM was porting Linux to mainframe.

I called IBM today and they confirmed that the development was going on, but they did



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GO TO....

## Linux/390 in the Spotlight at SHARE 94

by Jack J. Woehr

The atmosphere at SHARE 94 in Anaheim, California was nerdy beyond the ability of mere Unix hackers to imagine. Big draws at the conference, held March 5-10, 2000 at the Anaheim Hilton and Marriott, included sessions examining the latest updates to S/390 assembler programs and exhibits of computers the size of walk-in closets. Attendees included over three thousand members and scores of vendors displaying

[About Linux/390](#)

[About System 390](#)

[About Open Edition](#)

# Sidebar: s390? s390x?

s390 is 31-bit, for older mainframes.

...though sometimes people use it as an inaccurate shorthand for the IBM mainframe architecture

s390x is 64-bit, for modern mainframes (post 2000).

In 2015 with the Linux Kernel 4.1, Linux on Z became only compatible with 64-bit z/Architecture machines, but they are still backwards compatible with 31-bit applications.

# 20 Years of Linux

## Networking

Between Linux LPARs, HiperSocket is used for communication between VMs rather than TCP/IP for speed, responsiveness and reliability.

## Storage

Linux can connect and interface with to the storage servers, like the DS8880 and DS8888.

Portions of Linux rewritten to take advantage of hardware I/O capabilities reducing load from the Central Processor (CP).

## Processors

Linux can run on the traditional mainframe Central Processor (CP), but there's also an Integrated Facility for Linux (IFL) processor with some instructions disabled that are used only by z/OS.

## Open Source

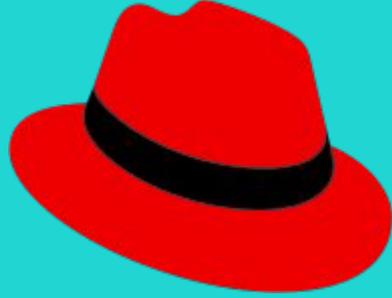
There are few barriers to compiling for s390x (though it is big-endian), so new open source software is being compiled for the platform every day.

Validated open source software list:

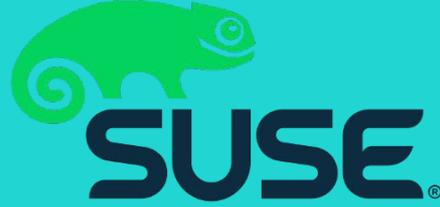
<https://www.ibm.com/developerworks/community/forums/html/topic?id=5dee144a-7c64-4bfe-884f-751d6308dbdf>

# Distributions (Official)

Red Hat Enterprise Linux



SUSE Enterprise Linux



Ubuntu



# Other Distributions

- Debian
- Fedora
- Slackware
- CentOS (ClefOS)
- Gentoo

# LinuxONE: Linux-only Mainframes



# LinuxONE

2015, Emperor and Rockhopper (z13 with IFLs)

IBM LinuxONE Emperor™



IBM LinuxONE Rockhopper™



# LinuxONE

2018, Emperor II and Rockhopper II (z14 with IFLs)

Meet the LinuxONE family



## IBM Emperor II

This top-of-the-line Linux system is engineered to help you deliver premium cloud services with pervasive encryption, lightning speed, and massive scalability.



## IBM Rockhopper II

The newest Linux server in the LinuxONE family offers many of the Emperor II's capabilities – and is sized to fit any cloud data center, from a startup to an established bank.

# Some cool things I learned



**Elizabeth K. Joseph**

@pleia2

First discovery? We live in a world of unreliable x86 hardware that we forgot was unreliable x86 hardware.

10:22 AM - 14 May 2019

<https://twitter.com/pleia2/status/1128349919608066048>



**Elizabeth K. Joseph**

@pleia2

And Docker has an architecture option under platform.

You can build identical containers across your environment, and when you need to offload to a different environment it's pretty easy to automate.

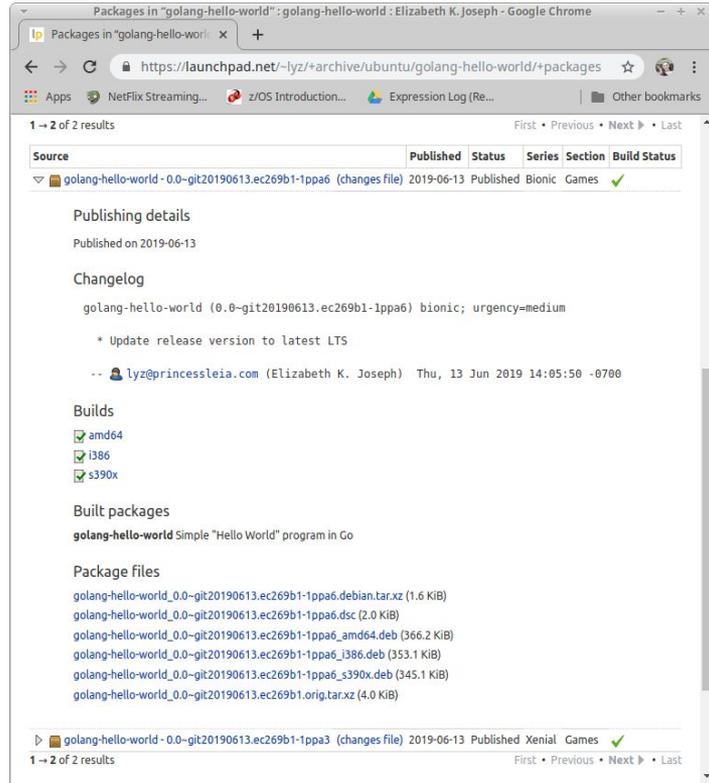
```
image: webapp:latest
manifests:
  -
    image: webapp-s390x
    platform:
      architecture: s390x
      os: linux
  -
    image: webapp-amd64
    platform:
      architecture: amd64
      os: linux
```

9:33 AM - 28 May 2019

<https://twitter.com/pleia2/status/1133410939523411968>

<https://hub.docker.com/u/s390x/>

# Self-Service s390x: Ubuntu PPAs



The screenshot shows a web browser window displaying the Launchpad page for the 'golang-hello-world' PPA. The page is titled 'Packages in "golang-hello-world": golang-hello-world: Elizabeth K. Joseph - Google Chrome'. The URL is 'https://launchpad.net/~lyz/+archive/ubuntu/golang-hello-world/+packages'. The page shows 2 results for the package 'golang-hello-world - 0.0-git20190613.ec269b1-1ppa6'. The package is published on 2019-06-13, is in the 'Published' status, and is for the 'Bionic' series, 'Games' section. The page includes a 'Publishing details' section with the date 'Published on 2019-06-13', a 'Changelog' section with the entry 'golang-hello-world (0.0-git20190613.ec269b1-1ppa6) bionic; urgency=medium' and a note '\* Update release version to latest LTS', and a 'Builds' section with links for 'amd64', 'i386', and 's390x'. The 'Built packages' section describes the package as 'Simple "Hello World" program in Go'. The 'Package files' section lists several files including 'golang-hello-world\_0.0-git20190613.ec269b1-1ppa6.debian.tar.xz (1.6 KiB)', 'golang-hello-world\_0.0-git20190613.ec269b1-1ppa6.dsc (2.0 KiB)', 'golang-hello-world\_0.0-git20190613.ec269b1-1ppa6\_amd64.deb (366.2 KiB)', 'golang-hello-world\_0.0-git20190613.ec269b1-1ppa6\_i386.deb (353.1 KiB)', 'golang-hello-world\_0.0-git20190613.ec269b1-1ppa6\_s390x.deb (345.1 KiB)', and 'golang-hello-world\_0.0-git20190613.ec269b1.orig.tar.xz (4.0 KiB)'. The page also shows a 'Package files' section with a link to 'golang-hello-world - 0.0-git20190613.ec269b1-1ppa3'.

See: <https://princessleia.com/journal/2019/06/building-a-ppa-for-s390x/>

# Self-Service s390x: openSUSE Build Service

The screenshot shows the openSUSE Build Service web interface for the 'snappy' package. The page includes a navigation bar with links for Downloads, Support, Community, and Development. The main content area is divided into several sections:

- Overview:** A fast compressor/decompressor library. Snappy is a compression/decompression library. It does not aim for maximum compression, or compatibility with any other compression library; instead, it aims for very high speeds and reasonable compression. For instance, compared to the fastest mode of zlib, Snappy is an order of magnitude faster for most inputs, but the resulting compressed files are anywhere from 20% to 100% bigger. On a single core of a Core i7 processor in 64-bit mode, Snappy compresses at about 250 MB/sec or more and decompresses at about 500 MB/sec or more. A note states: "Do NOT submit it to factory without asking or the package will be yours to maintain."
- Source Files:** A table showing unmerged sources with columns for Filename, Size, Changed, and Actions. The table lists files like 1.1.7.tar.gz, baselibs.conf, snappy-pcfile.patch, snappy.changes, and snappy.spec.
- Latest Revision:** A section indicating the latest revision was committed by Mark Post (markkp) 8 days ago (revision 1).
- Build Results:** A section showing the results of the build process for various architectures and platforms. The results are categorized by architecture (x86\_64, aarch64, s390x, armv7i) and platform (SLE\_12\_SP2, SLE\_12\_SP3, SLE\_12\_SP4, SLE\_15, openSUSE\_Factory, openSUSE\_Factory\_ARM, openSUSE\_Factory\_PowerPC, openSUSE\_Factory\_zSystems, openSUSE\_Leap\_15.0, openSUSE\_Leap\_15.1, openSUSE\_Leap\_42.3).

Filename	Size	Changed	Actions
1.1.7.tar.gz	1.04 MB	2018-02-08	<a href="#">Download</a>
baselibs.conf	11 Bytes	2015-07-29	<a href="#">Download</a>
snappy-pcfile.patch	2.43 KB	2018-02-08	<a href="#">Download</a>
snappy.changes	4.53 KB	2018-02-08	<a href="#">Download</a>
snappy.spec	3.07 KB	2018-02-08	<a href="#">Download</a>

Architecture	Platform	Result
x86_64	SLE_12_SP2	failed
aarch64	SLE_12_SP3	successful
ppc64le	SLE_12_SP3	successful
s390x	SLE_12_SP3	successful
x86_64	SLE_12_SP4	successful
aarch64	SLE_12_SP4	successful
ppc64le	SLE_12_SP4	successful
s390x	SLE_12_SP4	successful
x86_64	SLE_15	successful
s390x	SLE_15	successful
i586	openSUSE_Factory	successful
x86_64	openSUSE_Factory_ARM	successful
armv7i	openSUSE_Factory_ARM	successful
aarch64	openSUSE_Factory_PowerPC	successful
ppc64	openSUSE_Factory_PowerPC	successful
ppc64le	openSUSE_Factory_PowerPC	successful
s390x	openSUSE_Factory_zSystems	successful
x86_64	openSUSE_Leap_15.0	successful
x86_64	openSUSE_Leap_15.1	successful
x86_64	openSUSE_Leap_42.3	successful

Source: <https://build.opensuse.org/>

# LinuxONE Community Cloud

The IBM LinuxONE Community Cloud provides a no charge, self-provisioned SUSE or Red Hat virtual machine on an IBM LinuxONE Enterprise Server (s390x architecture) to develop, test, and run your apps.

<https://developer.ibm.com/linuxone>



# Some cool things I learned, cont.



Elizabeth K. Joseph  
@pleia2

One of the reasons I hopped on board with this [#LinuxONE](#) adventure was how integrated the tooling was with existing open source solutions.

Want to use the in-processor crypto? It's not an awkward, bolted-on, IBM-only solution. You just configure [#OpenSSL](#) to use it. [#IBMZ](#)

```
locate the OpenSSL distribution in this directory
/etc/pki/tls
Make a backup copy of the openssl.cnf file
Example 4-4 Backup copy of the openssl.cnf
[root@tso1nx2 ~]# ls -la /etc/pki/tls/openssl1.cnf
-rw-r--r-- 1 root root 12376 Sep 25 14:25 /etc/pki/tls/openssl1.cnf
[root@tso1nx2 ~]# cp -p /etc/pki/tls/openssl1.cnf /etc/pki/tls/openssl1.cnf.backup
[root@tso1nx2 ~]# ls -al /etc/pki/tls/openssl1.cnf
-rw-r--r-- 1 root root 10923 Sep 25 14:25 /etc/pki/tls/openssl1.cnf
-rw-r--r-- 1 root root 10923 Sep 25 14:26 /etc/pki/tls/openssl1.cnf.backup
Some ibmca related content must be appended to the openssl.cnf file. This code
with the openssl-ibmca package. Therefore, locate the ibmca package (Example
look for a file called openssl1.cnf.sample.s390x.
Example 4-5 Locate the ibmca sample file
[root@tso1nx2 ~]# find / -name openssl1.cnf.sample.s390x -type f
/usr/share/doc/openssl-ibmca-1.3.0/openssl1.cnf.sample.s390x
[root@tso1nx2 ~]# ls -al
-rw-r--r-- 1 root root 1396 Mar 31 04:35
/usr/share/doc/openssl-ibmca-1.3.0/openssl1.cnf.sample.s390x
4. Now, append the ibmca-related configuration lines to the OpenSSL configuration
(Example 4-6).
```

8:54 AM - 17 Jun 2019

<https://twitter.com/pleia2/status/1140649031481167872>



Elizabeth K. Joseph  
@pleia2

Cloud or on-prem [#mainframe](#)? Turns out you don't strictly have to choose in order to take advantage of hardware-driven cryptographic key handling and encryption.

This week I wrote an article with [@mentorafrika](#) about [#IBMCloud](#) [#HyperProtect](#) Services!



**IBM Cloud Hyper Protect Services: Protect your organizatio...**

Powered by LinuxONE, IBM Cloud Hyper Protect Services provide a proven, hardware-driven cryptography back end to quickly and efficiently encrypt all of your data.

developer.ibm.com

9:00 AM - 14 Jun 2019

<https://twitter.com/pleia2/status/1139563222187405313>

<https://developer.ibm.com/blogs/hyper-protect-services-protect-your-org-from-internal-and-external-threats/>

# Cryptography in the Cloud, powered by Linux on Z

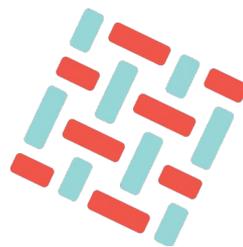
IBM Cloud Hyper Protect Services:  
Crypto, DBaaS, Virtual Servers, and  
Containers (soon)

<https://www.ibm.com/cloud/hyper-protect-services>



IBM Blockchain Platform

<https://www.ibm.com/cloud/blockchain-platform>



**HYPERLEDGER**  
**FABRIC**

# So, what does Linux on the mainframe excel at?

- Hardware cryptographic functions, with both a cryptographic co-processor on every processor AND a FIPS 140-2 Level 4 certified Hardware Security Module (HSM), Crypto Express Card for secure key handling.
  - Full virtualization (not paravirtualization) with decades of experience behind it
  - Offloading of I/O to a separate machine (DS8800, DS8880, DS8888...)
  - Redundant... everything. You can even cluster mainframes with Geographically Dispersed Parallel Sysplex (GDPS), which can be used for Linux VMs
  - Hot-swappable hardware, including memory and processors
- Consolidation of resources into one box instead of a fleet of x86 machines, conserving resources used to manage individual servers (non-trivial)



Elizabeth K. Joseph  
@pleia2

Specifically I've learned that things like storage and networking are Solved Problems in a mainframe infrastructure. Those are key pieces that go wrong in distributed systems and you end up burning tons of unscheduled time on them. It seems easier, until you get into the details.

9:34 AM - 24 Jun 2019

<https://twitter.com/pleia2/status/1143195614076796928>

The Future!



# Energy Savings

Paul Newton: The world can't take all the x86 machines we'll need at the rate server farms are growing.

Me: Cost or, like, the planet?

PN: Yes.

We will encrypt more stuff

Need for fewer impactful data breaches (stolen data is useless if it's encrypted!)

More laws and regulations around access and use of customer data.

In addition to the FIPS 140-2 Level 4 HSM, Linux on Z is Evaluation Assurance Level (EAL) 4+ (the Z mainframes themselves are 5+)

# Further Architecture Diversification

We're now seeing an increase in hardware architectures, not a decrease!

Every year we have more compelling reasons to not solely depend upon x86  
(Meltdown, Spectre...)

# Thank you.

Elizabeth K. Joseph

Developer Advocate, IBM Z

—

[lyz@ibm.com](mailto:lyz@ibm.com) | [lyz@princessleia.com](mailto:lyz@princessleia.com)

## Resources

Melinda Varian's Home Page (for "VM and the VM Community: Past, Present, and Future" paper):

<http://www.leeandmelindavarian.com/Melinda/>

Linux on the IBM ESA/390 Mainframe Architecture:

<https://linas.org/linux/i370.html>

[https://en.wikipedia.org/wiki/Linux\\_on\\_z\\_Systems](https://en.wikipedia.org/wiki/Linux_on_z_Systems)

Meet the Mainframe with Esmeralda Quintana:

<https://www.youtube.com/watch?v=C1YGE7m33iQ>

LinuxONE Community Cloud: <https://developer.ibm.com/linuxone>

## Credits

Paul Newton

Jenn Francis

Anna Shugol

Matthew Cousens

Leon Kiriliuk

Jeff Bisti

