



THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
NORTH AMERICA

Exploring 20 Years of Linux and Open Source on the Mainframe

Elizabeth K. Joseph, IBM

#ossummit @pleia2



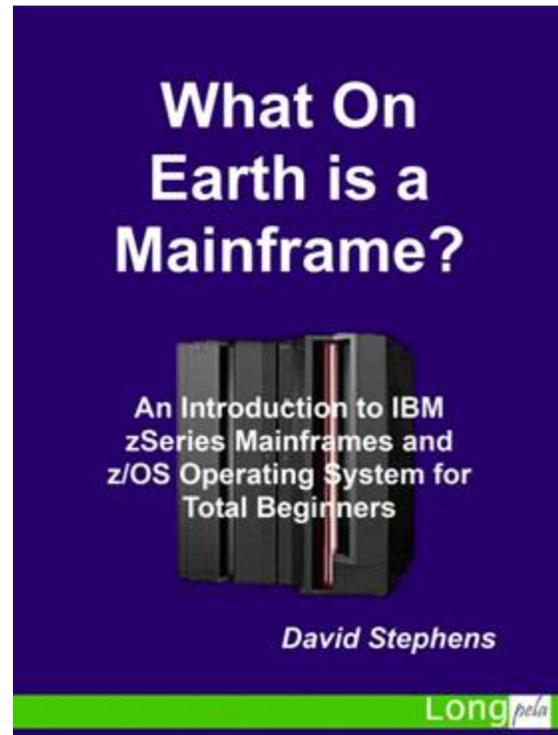
- Debian and Ubuntu
- OpenStack
- Apache Mesos
- ...and now mainframes? Yep!

What is a mainframe?

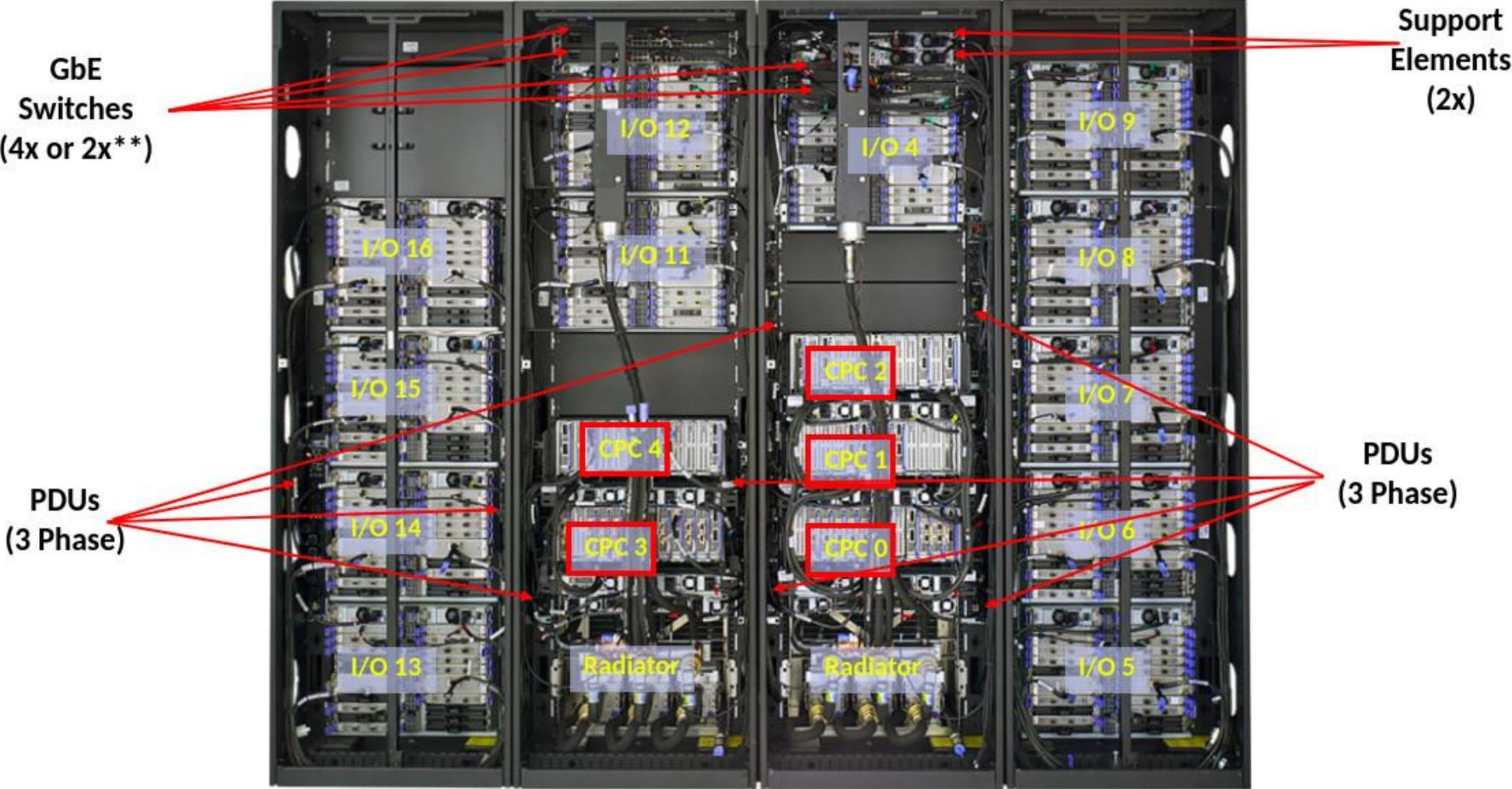


What is a mainframe?

Data, data, data.



What is a mainframe?



What is a mainframe?

Not x86.

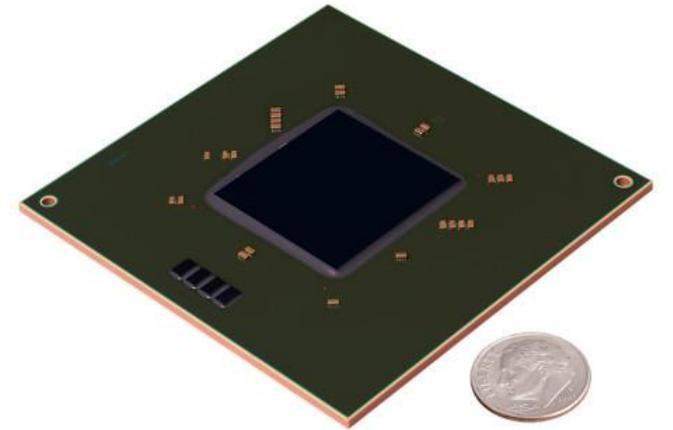
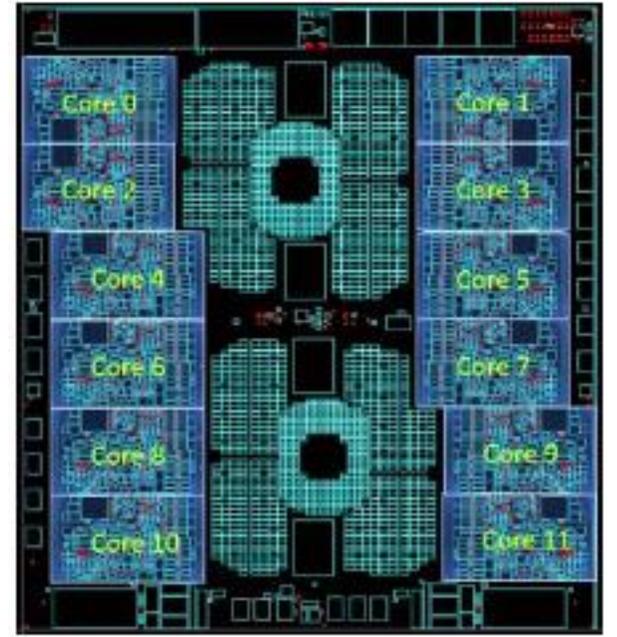
(IBM Z | zArchitecture | s390x)

190 5.2 ghz processor units (PUs), with 12 cores per chip

But also...

- 40TB of RAM
- 60 PCIe control units across 12 PCIe I/O drawers
- 22 dedicated I/O offload processors (SAPs) pre-allocated per system

<https://developer.ibm.com/blogs/systems-inside-the-new-ibm-z15/>



Storage - DS8900F

The highest end model, the IBM DS8950F Model 996 has nearly 5.9 PB (5,898 TB) maximum physical capacity

But also...



Storwize® V5100/F



Storwize V7000



FlashSystem® 9100



FlashSystem 900



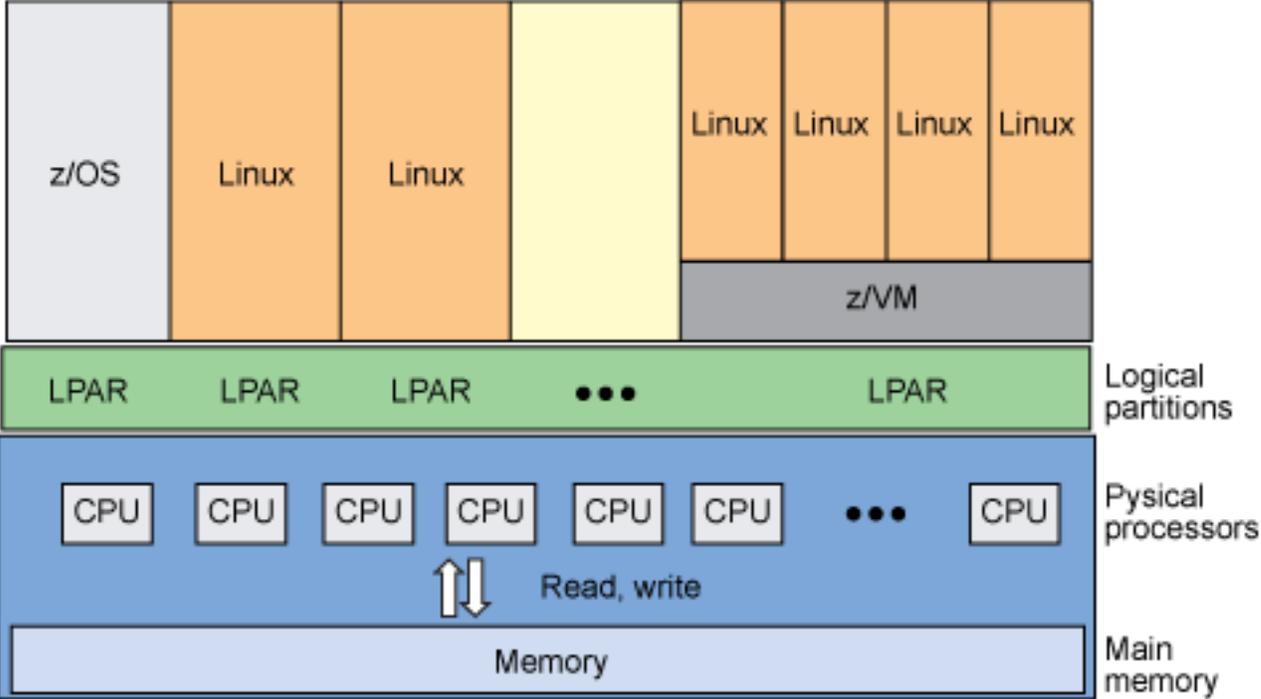
DS8882F



Modern mainframes run Linux!

...and they have for 20+ years

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).

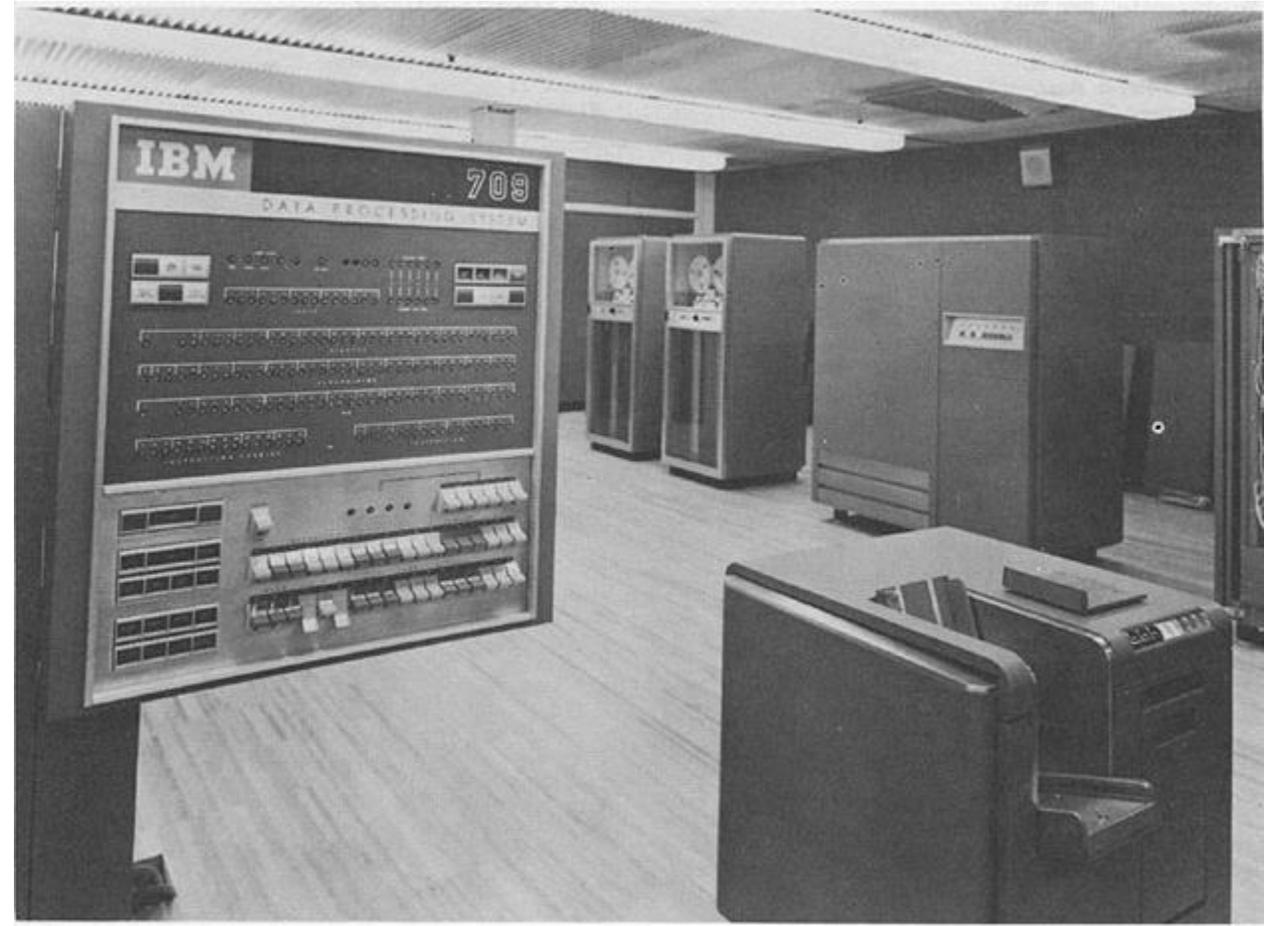
Using Processor Resource and System Manager (PR/SM) a single Linux instance can be installed on a single LPAR.

<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.

Compatible Time-Sharing System (CTSS) was
first demoed by MIT on an IBM 709 in 1961.



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



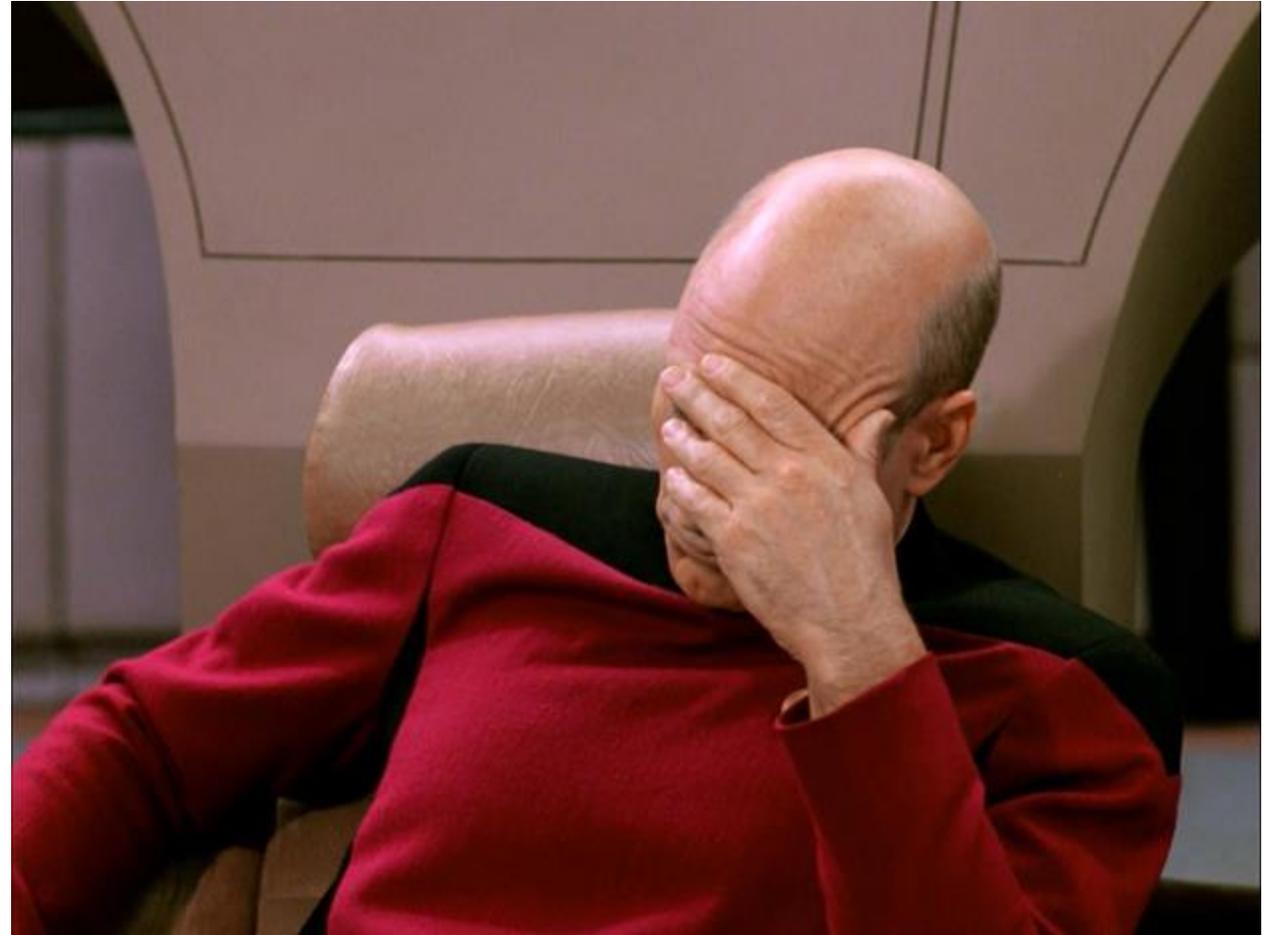
Want to know about all those iterations? Melinda Varian has published a fascinating history, available in several formats, on her website:

<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.

This was a big step forward, previously they had been focused on the proprietary IBM Systems Network Architecture (SNA) for connecting servers.

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

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>

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

Dr. Dobb's

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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](#)

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 DS8900F.

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

Processors

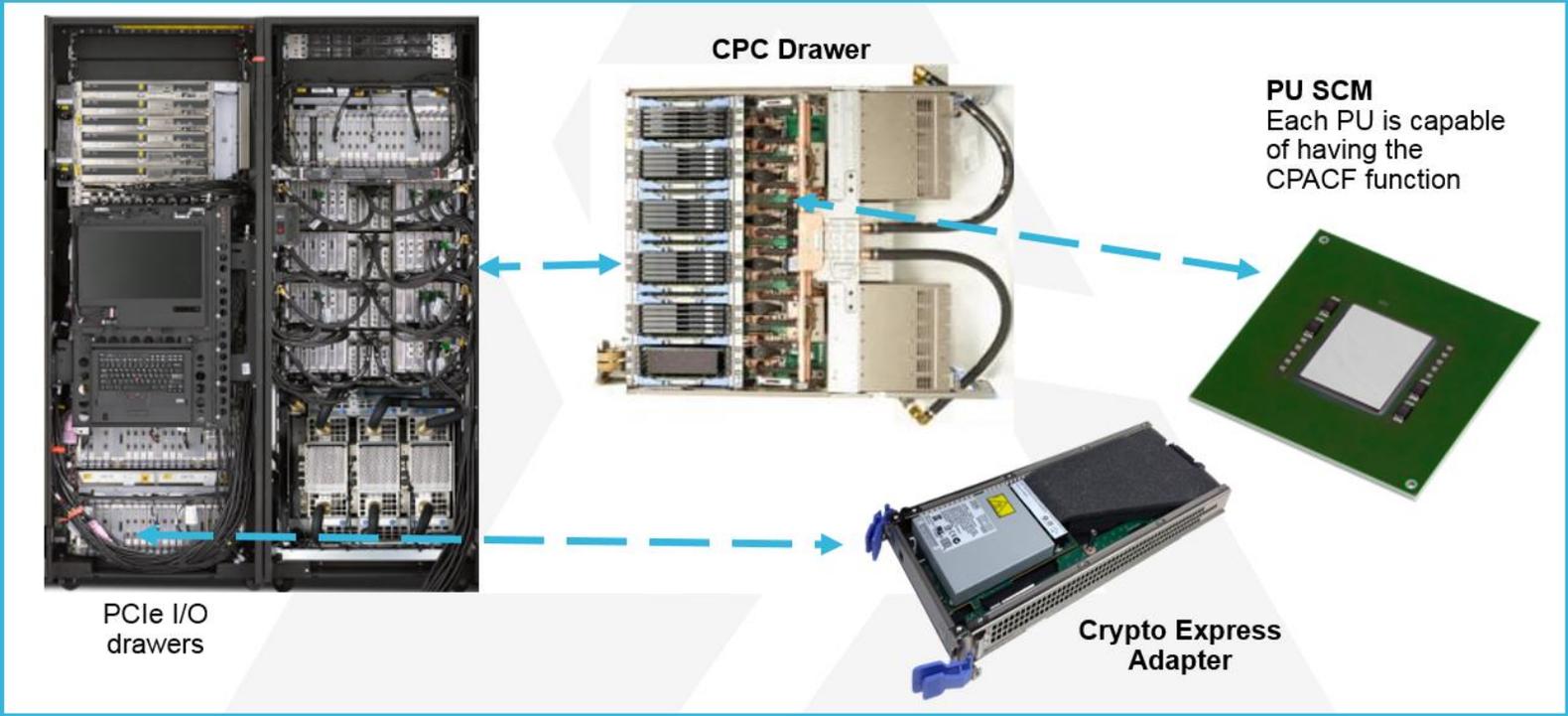
Linux can run on the traditional mainframe Central Processor (CP), but there's also an Integrated Facility for Linux (IFL) processor with some instructions disabled that are used only by z/OS.

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/community/z/open-source-software/>

Encryption



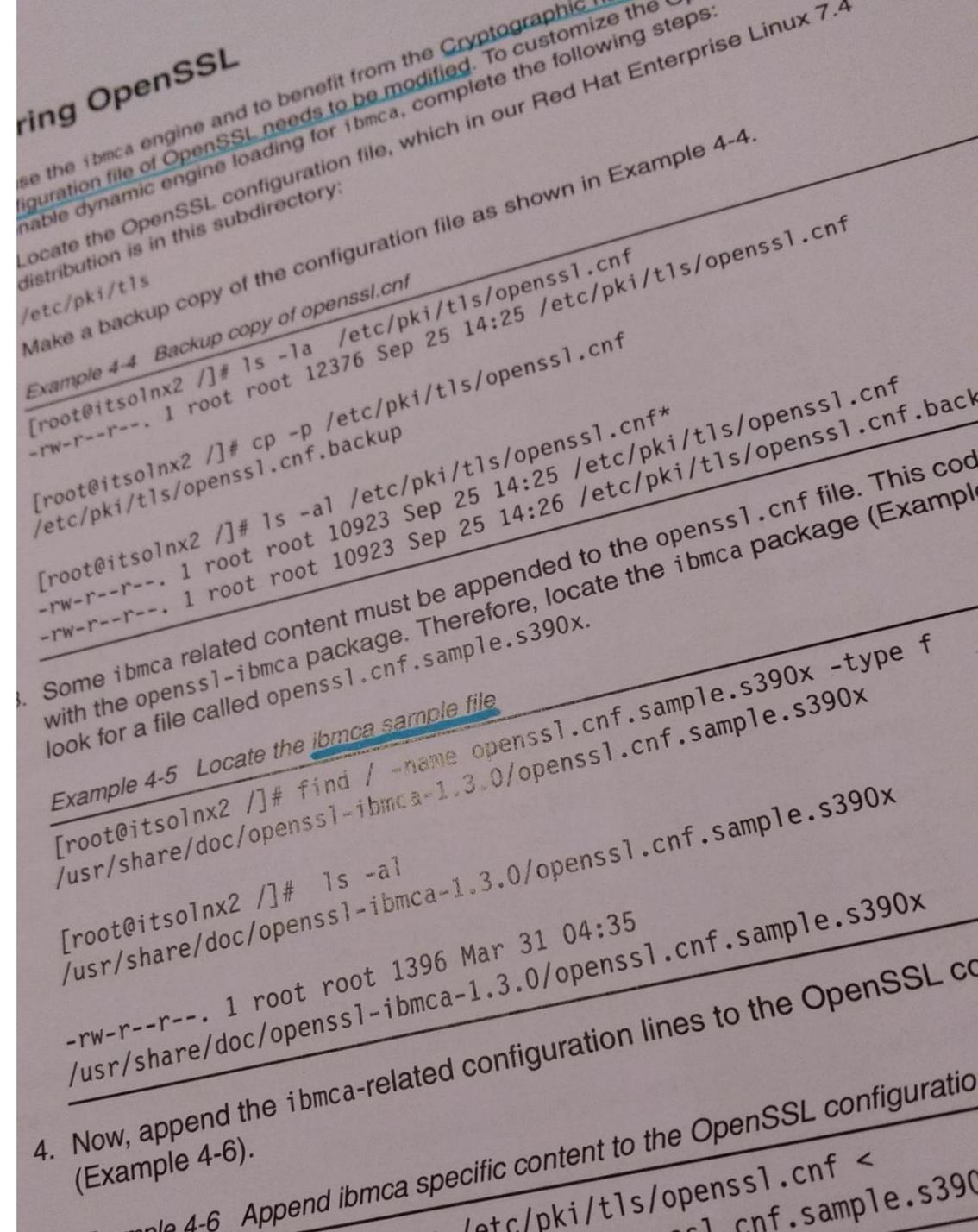
How it's used on Linux

Security for Linux on System Z

<http://www.redbooks.ibm.com/abstracts/sg247728.html>

- dm-crypt
- OpenSSL and libcrypto (including for ssh, scp, sftp, Apache mod_ssl...)
- IPsec

And the open source libica crypto library for s390x <https://github.com/opencryptoki/libica>



LinuxONE

2019, LinuxONE III (z15 with IFLs)



Distributions

Hypervisors

PaaS / IaaS

Languages

Runtimes

Management

Database

Analytics



LPAR



Community Versions



DPM



CentOS



<https://www.ibm.com/community/z/open-source-software/>

Verified Software List

Packages	RHEL 8.x	Ubuntu 20.x	SLES 15.x	Dockerfile/Image	RHEL 7.x	Ubuntu 18.x	SLES 12.x	Ubuntu 16.x	New Test
Alfresco	5.x	NA	5.x	5.x image	5.x	5.x	5.x	5.x	NA
Ansible	Latest	Distro Latest	Latest	Image Latest	Latest	Distro Latest	Distro Latest	Distro Latest	NA
AntLR	4.x	Distro 4.x	4.x	4.x Image	3.x, 4.x	Distro 3.x, 4.x	3.x, 4.x	Distro 3.x, 4.x	NA
Apache ActiveMQ	Latest	Distro Latest	Latest	5.x Image	Latest	Distro Latest	Latest	Distro Latest	NA
Apache Camel	Download	NA	Download	NA	Download	Download	Download	Download	NA
Apache Cassandra	NA	NA	3.x	3.x Image	2.x, 3.x	2.x, 3.x	2.x, 3.x	2.x, 3.x	NA

<https://www.ibm.com/community/z/open-source-software/>

Docker Hub

Operating Systems

- Linux
- Windows

Architectures

- ARM
- ARM 64
- IBM POWER
- IBM Z
- PowerPC 64 LE
- x86
- x86-64

https://hub.docker.com/_/alpine



alpine
Updated 18 minutes ago

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A minimal Docker image based on Alpine Linux with a complete package index ...

Container Linux ARM 64 x86-64 ARM IBM Z 386 PowerPC 64 LE

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The PostgreSQL object-relational database system provides reliability and data i...

Container Linux ARM IBM Z 386 ARM 64 x86-64 PowerPC 64 LE

mips64le Databases



node

OFFICIAL IMAGE

10M+ Downloads 9.0K Stars

Easy porting: Java and Go

Java has been a staple of mainframe technology for decades now.

Some of the first open source tooling brought to the mainframe was around

Java, as Trevor Eddolls writes in a recent blog post:

"If you are working with IMS and like using Java, you can use Spring Boot, Hibernate, JPA, and ORM."

And continues:

"They [IBM] also created a Maven plugin for authoring CICS bundles, which can be used directly in a Java application build toolchain. And they created a Gradle plugin for authoring CICS bundles, which can be used directly in a Java application build toolchain."

<https://it.toolbox.com/blogs/trevoreddolls/mainframes-and-open-source-tools-061420>

Support for s390x was added as experimental in

Go 1.7 <https://golang.org/doc/go1.7> (2016)

Today, if your application is written in Go, there's a pretty good chance it'll compile and run fine on Linux on Z.

The crypto/aes package in Go uses hardware-based encryption: "The AES operations in this package are not implemented using constant-time algorithms. An exception is when running on systems with enabled hardware support for AES that makes these operations constant-time. Examples include amd64 systems using AES-NI extensions and **s390x** systems using Message-Security-Assist extensions."

Integration Layers

Swagger is being used extensively as we tie traditional z/OS workloads with modern front-ends.

COBOL has native support for XML and JSON, allowing for Enterprise COBOL being run on the mainframe to directly interact with front-ends.

<https://developer.ibm.com/technologies/cobol/blogs/cobol-programming-past-present-future/>



A Linux Foundation Project, the Open Mainframe Project:

"is intended to serve as a focal point for deployment and use of Linux and Open Source in a mainframe computing environment. The Project intends to increase collaboration across the mainframe community and to develop shared tool sets and resources. Furthermore, the Project seeks to involve the participation of academic institutions to assist in teaching and educating the mainframe engineers and developers of tomorrow."

Open Mainframe Project projects:

<https://www.openmainframeproject.org/projects>

Zowe website: <https://www.zowe.org/>

Zowe Overview (November 2018):

<https://www.youtube.com/watch?v=NX20ZMRoTtk>

Zowe Webinar (22 February 2019):

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

Here at the summit, Joe Winchester did a session on **“How Open Mainframe Project’s Zowe is Opening up the Mainframe. Who Says You Can’t Teach Old Dogs New Tricks.”** keep an eye out for the recording!

<https://ossna2020.sched.com/event/c3PD/how-open-mainframe-projects-zowe-is-opening-up-the-mainframe-who-says-you-cant-teach-old-dogs-new-tricks-joseph-winchester-ibm>



OPEN **MAINFRAME** PROJECT

Zowe

Zowe

Zowe is a new open source software framework that provides solutions that allow development and operations teams to securely, manage, control, script and develop on the Mainframe like any other cloud platform. Zowe is the first open source project based on z/OS.

Traditional interaction: ISPF

(Interactive System Productivity Facility)

```
Menu Utilities Compilers Options Status Help
-----
ISPF Primary Option Menu
Option ==> 

0 Settings Terminal and user parameters User ID . : Z51005
1 View Display source data or listings Time. . . : 14:42
2 Edit Create or change source data Terminal. : 3278
3 Utilities Perform utility functions Screen. . : 1
4 Foreground Interactive language processing Language. : ENGLISH
5 Batch Submit job for language processing Appl ID . : ISR
6 Command Enter TSD or Workstation commands TSD logon : DBPROCBG
7 Dialog Test Perform dialog testing TSD prefix: Z51005
8 LM Facility Library administrator functions System ID : S0W1
9 IBM Products IBM program development products MVS acct. : FB3
10 SCLM SW Configuration Library Manager Release . : ISPF 7.3
11 Workplace ISPF Object/Action Workplace

----- Other Functions -----

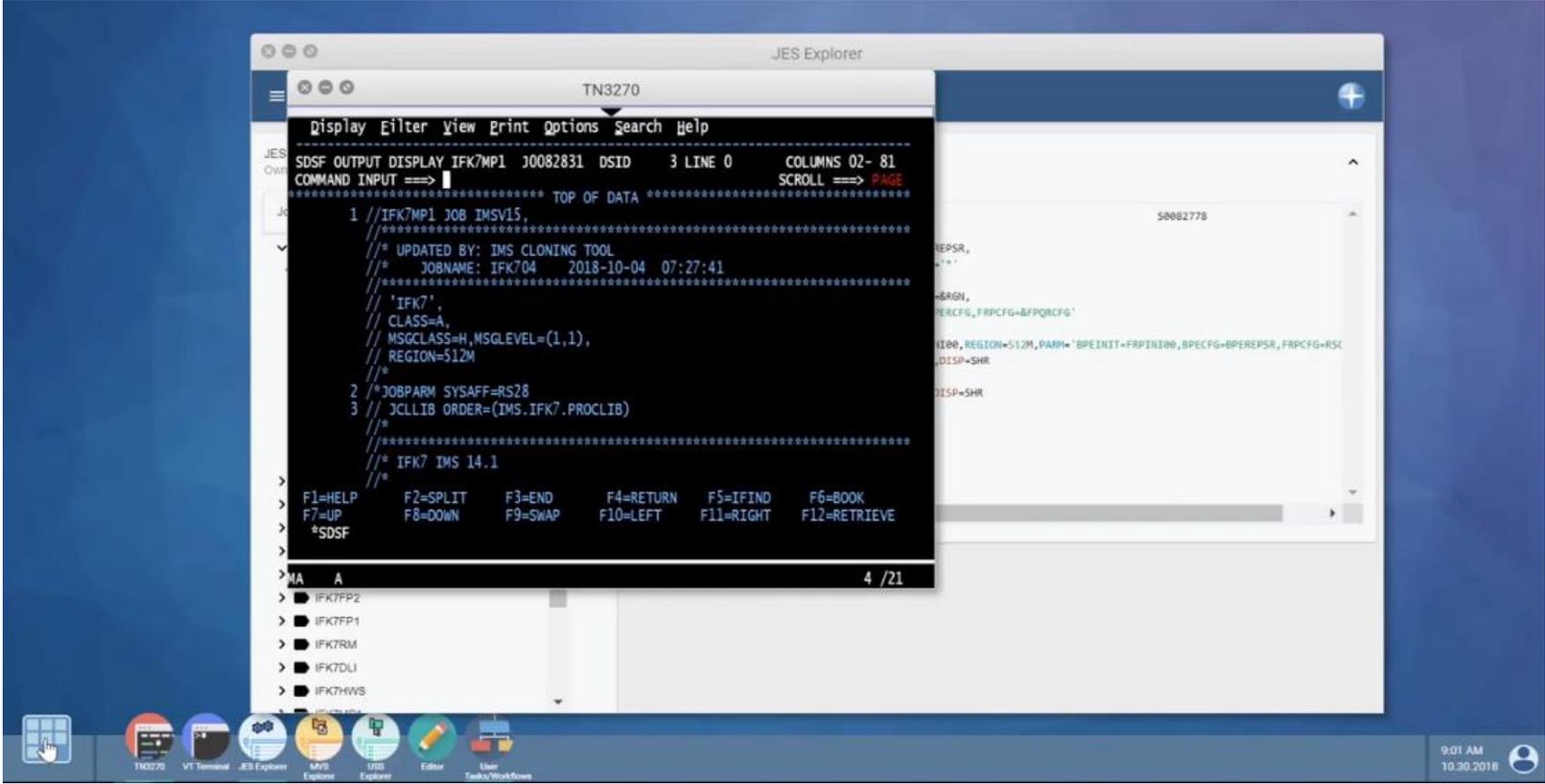
SD SDSF View output
U Unix Unix Shell Prompt
UF Unix Files Unix Services
D2 DB2I DB2 Interactive functions
DM DB2ADM DB2 Administration
F File Manager File Manager for z/OS
IS ISMF Disk Storage Management
SM SMP/E Software Installation and Management
IP IPCS Debug System Dumps and Traces
HC HCD System Device Management
FD FM/DB2 File Manager/DB2
FI FM/IMS File Manager/IMS

Enter X to Terminate using log/list defaults

F1=Help F2=Split F3=Exit F7=Backward F8=Forward F9=Swap
F10=Actions F12=Cancel

TCP00446 004/014
```

Modern interaction: Zowe Web Desktop



- Desktop-like environment, in your web browser
- Includes a 3270 terminal
- Provides GUI-based explorers for files and datasets with ways to manipulate data

Modern interaction: Zowe CLI

Modern command line tool

- Execute zowe commands from standard MacOS/Linux terminal
- Includes core commands for interacting with mainframe-specific needs (TSO, batch processing)
- Extendable for your specific needs, or those of vendors who wish to offer support for their tooling

Can build IDE extensions, a Visual Studio Code extension already exists.

Automation and scripting, including CI/CD pipelines!

Example usage, Using the Zowe CLI to edit a data set:

<https://docs.zowe.org/stable/user-guide/zowe-getting-started-tutorial.html#using-the-zowe-cli-to-edit-a-data-set>

Modern interaction: Zowe API

API gateway that can abstract out the various number of services running on the mainframe that you may wish to interact with: job services, dataset services, and more

Open source and vendor products are now leveraging the API for new products that interact with the mainframe

Other Open Mainframe Projects



Ambitus

Ambitus fosters a community that will help educate developers about all open source technologies on z/OS



Anomaly Detection Engine for Linux Logs (ADE)

ADE detects anomalous time slices and messages in Linux logs (either RFC3164 or RFC5424 format) using statistical learning.



Atom language syntax highlighting for z/VM

Helping connect the next generation with mainframe and open source, the internship program has help students over the past several years become contributors to open source on mainframe, as well as develop the skills for a long career in technology.

Other Open Mainframe Projects



Feilong

Feilong is an open source z/VM cloud connector project under the Open Mainframe Project umbrella that will accelerate the z/VM adoption, extending its ecosystem and its user experience.



Mentorship Program

Helping connect the next generation with mainframe and open source, the mentorship program has helped students over the past several years become contributors to open source on mainframe, as well as develop the skills for a long career in technology.



Polycephaly

Polycephaly enables developers to build z/OS source code files with Jenkins and Git

Other Open Mainframe Projects



TerseDecompress

TerseDecompress helps mainframe users uncompress files on any workstation.



Zorow

z/OS Open Repository of Workflows (zorow), is dedicated to contributing and collaborating on z/OSMF workflows.

And more new projects!

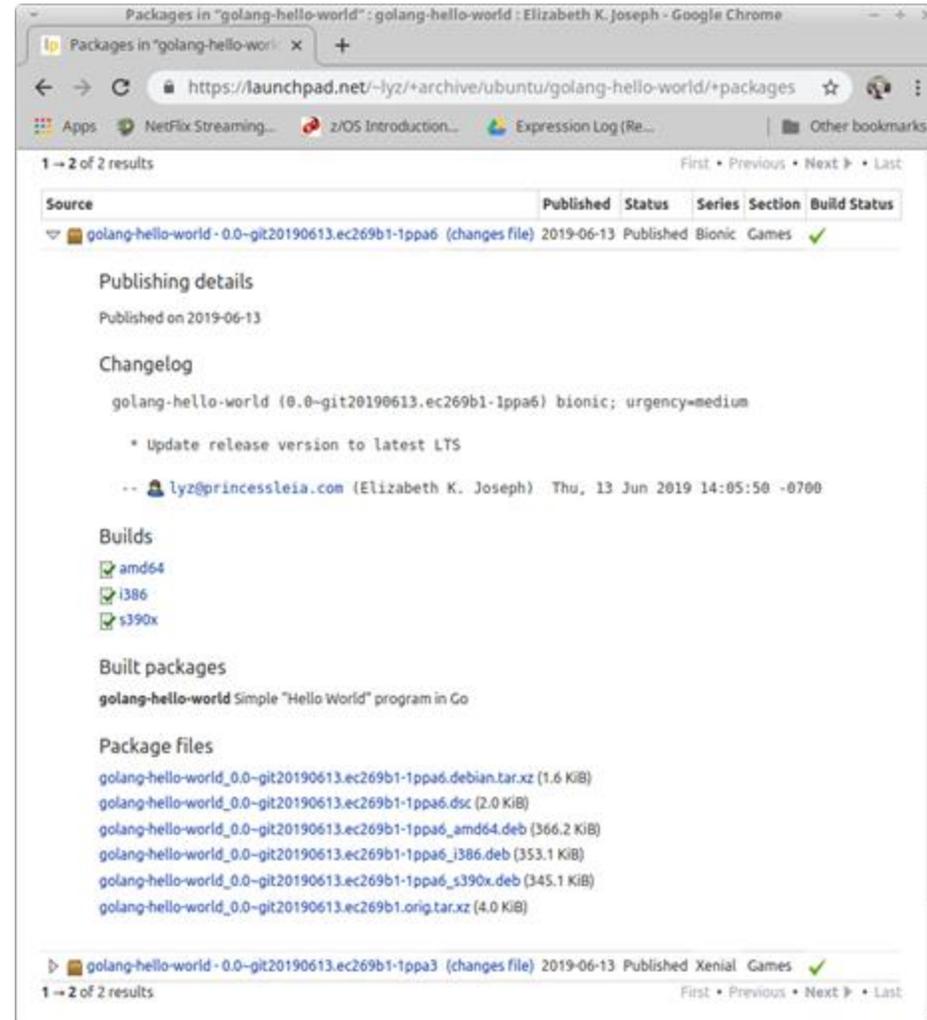
- cobol-programming-course
- software-discovery-tool
- omp-education

GitHub Project: <https://github.com/openmainframeproject>

Your software?

Build it for the mainframe!

Self-Service s390x: Ubuntu PPAs



The screenshot shows a web browser window displaying the Launchpad page for the PPA 'golang-hello-world'. 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 Bionic series. The first result is 'golang-hello-world - 0.0-git20190613.ec269b1-1ppa6' published on 2019-06-13. The page includes sections for 'Publishing details', 'Changelog', 'Builds', 'Built packages', and 'Package files'. The 'Builds' section lists amd64, i386, and s390x. The 'Package files' section lists various package files including debian.tar.xz, dsc, amd64.deb, i386.deb, s390x.deb, and orig.tar.xz.

Source	Published	Status	Series	Section	Build Status
golang-hello-world - 0.0-git20190613.ec269b1-1ppa6 (changes file)	2019-06-13	Published	Bionic	Games	✓

Publishing details
Published on 2019-06-13

Changelog
golang-hello-world (0.0-git20190613.ec269b1-1ppa6) bionic; urgency=medium
* Update release version to latest LTS
-- lyz@princessleia.com (Elizabeth K. Joseph) Thu, 13 Jun 2019 14:05:50 -0700

Builds
amd64
i386
s390x

Built packages
golang-hello-world Simple "Hello World" program in Go

Package files
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)
golang-hello-world_0.0-git20190613.ec269b1.orig.tar.xz (4.0 KiB)

golang-hello-world - 0.0-git20190613.ec269b1-1ppa3 (changes file)	2019-06-13	Published	Xenial	Games	✓
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<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' project. The page is divided into several sections:

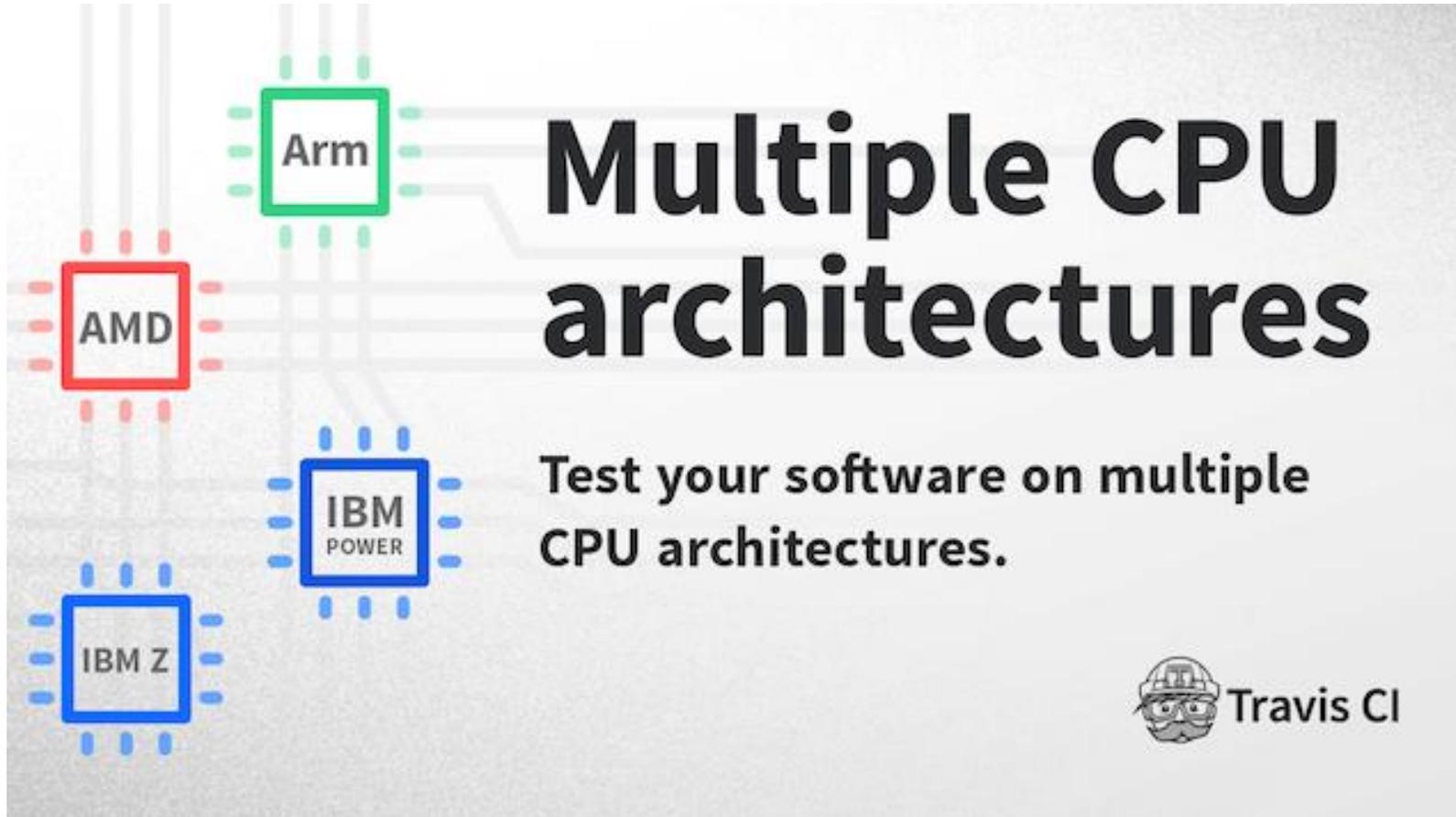
- Header:** Includes navigation links for Downloads, Support, Community, and Development, along with a search bar and 'Sign Up | Log In' options.
- Project Overview:** Displays the project name 'snappy' and a description: 'A fast compressor/decompressor library'. It includes a warning: 'Do NOT submit it to factory without asking or the package will be yours to maintain.'
- Source Files:** A table listing source files with columns for Filename, Size, Changed, and Actions. The files listed are 1.1.7.tar.gz, baselibs.conf, snappy-pcfile.patch, snappy.changes, and snappy.spec.
- Latest Revision:** Shows a commit by Mark Post (markkp) committed 6 days ago (revision 1).
- Build Results:** A table showing build results for various architectures and OS versions. The 'snappy' package is shown with a 'failed' status for SLE_12_SP2 on x86_64 and 'succeeded' for all other architectures and OS versions.

Filename	Size	Changed	Actions
1.1.7.tar.gz	1.04 MB	2018-02-08	
baselibs.conf	11 Bytes	2015-07-29	
snappy-pcfile.patch	2.43 KB	2018-02-08	
snappy.changes	4.53 KB	2018-02-08	
snappy.spec	3.07 KB	2018-02-08	

Architecture	Status
x86_64	failed
aarch64	succeeded
ppc64le	succeeded
s390x	succeeded
x86_64	succeeded
aarch64	succeeded
ppc64le	succeeded
s390x	succeeded
x86_64	succeeded
s390x	succeeded
i586	succeeded
x86_64	succeeded
armv7l	succeeded
aarch64	succeeded
ppc64	succeeded
ppc64le	succeeded
s390x	succeeded
x86_64	succeeded
x86_64	succeeded
x86_64	succeeded

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

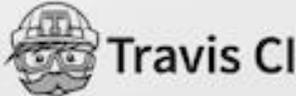
Self-Service s390x: Travis CI



The image is a promotional graphic for Travis CI. It features a light gray background with a faint grid pattern. On the left side, there are four stylized CPU chip icons: a red-bordered square labeled 'AMD', a green-bordered square labeled 'Arm', a blue-bordered square labeled 'IBM Z', and a blue-bordered square labeled 'IBM POWER'. Lines connect these icons to the main text on the right. The main text reads 'Multiple CPU architectures' in a large, bold, black font. Below this, in a smaller black font, it says 'Test your software on multiple CPU architectures.' In the bottom right corner, there is the Travis CI logo, which is a stylized character wearing a hard hat and glasses, followed by the text 'Travis CI'.

Multiple CPU architectures

Test your software on multiple CPU architectures.



<https://blog.travis-ci.com/2019-11-12-multi-cpu-architecture-ibm-power-ibm->

Unleash the power to innovate with IBM **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>

Thank you!

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@pleia2



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