Running .NET Workloads on IBM Z

Ulrich Weigand

ulrich.weigand@de.ibm.com

Agenda

- What is IBM Z?
- Linux on IBM Z and LinuxONE
- Porting .NET 6 to IBM Z
- .NET on RHEL and OpenShift
- Demo
- Porting .NET applications to IBM Z
- Summary

IBM Z History

- System/360
- System/370
- System/390
- IBM zSeries
- IBM System z
- IBM z Systems
- IBM Z
- LinuxONE

IBM System/360 Model 75

used by NASA for the Apollo 11 mission

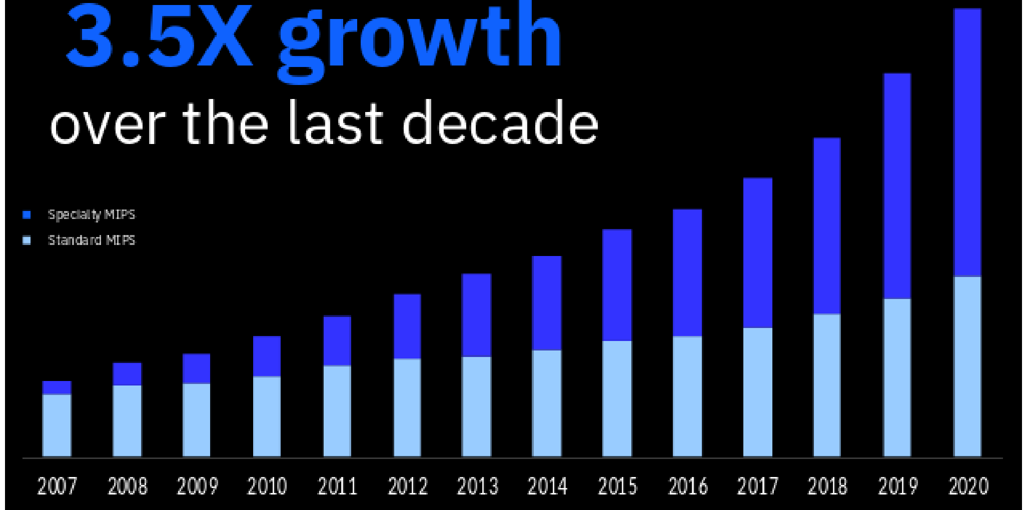
IBM z15

IBM Z Use Cases

- Low Latency and Large Volume **Data Serving** and **Transaction processing**
  - Up to 190 cores dedicated to business logic
  - Up to 30 cores dedicated to I/O processing
  - Up to 320 I/O channel processors
- Enterprise class infrastructure – **Elastic, Scalable, Available and Resilient**
  - Extreme Virtualization and Scale – “Cloud in a box”
    - 85 partitions per box; >1k virtual machines; >2 million containers
    - 40TB memory
  - High availability and resiliency across the system
    - ECC everywhere, transparent core failover
    - Concurrent microcode update & hardware replacement
- Highest levels of **Security and Compliance**
  - Hardware Security Module (HSM) - FIPS142-2 lvl4 certified
  - EAL 5+ isolation and virtualization
  - Secure Service Container – secure enclave for applications

3.5X growth

over the last decade



67 of the Fortune 100

45 of the world’s top 50 banks

8 of the top 10 insurers

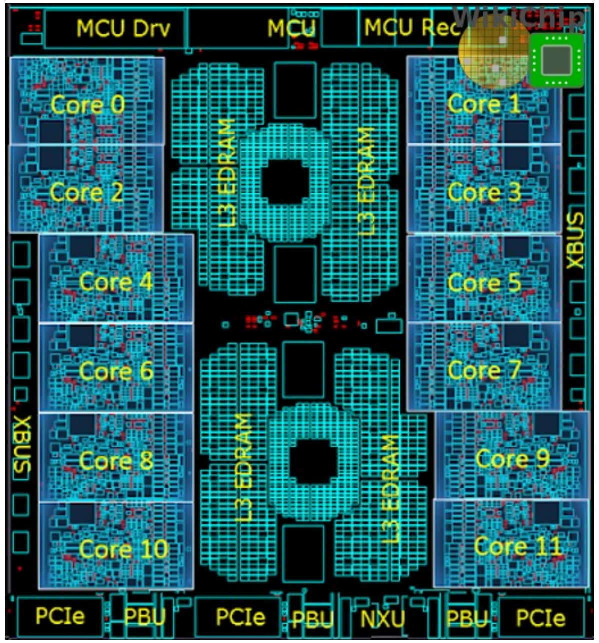
4 of the top 5 airlines

7 of the top 10 global retailers

8 out of the top 10 telcos

IBM Z Processor Architecture

- IBM Z processors implement z/Architecture
  - Direct successor of System/360 architecture
  - CISC, 64-bit, 16 GPRs, 16 FPRs, 32 VRs, ~2000 instructions
  - Documented in the z/Architecture Principles of Operation
    - `https://www.ibm.com/support/pages/zarchitecture-principles-operation`
- Hardware-assist capabilities
  - Multi-level TLBs for high-perf nested virtualization and scale
  - Built-in error detection and correction for high availability
  - High-perf crypto co-processor per-core for security
  - Pause-less Garbage Collection for Java
  - Built-in compression accelerator for databases
- Next-gen Telum chip to include AI accelerator (Hot Chips 33)



5.2 GHz clock speed

L1 cache and L2 cache on core

L3 cache on chip

14nm SOI Technology

17 layers of metal

9.2 Billion Transistors

Chip Area 25.3 x 27.5 mm

Linux on IBM Z and LinuxONE

- Traditional operating systems on Z: z/OS, z/VSE, z/TPF, z/VM
- Since 2000, Linux is also available on IBM Z (s390x)
  - Linux distributions with enterprise support on Z:

    SUSE Red Hat ubuntu

  - Community distros: Fedora, OpenSUSE, Debian, CentOS, Alpine, …
- Why Linux on IBM Z?
  - Best of both worlds: combine HW capabilities of Z with the vast software ecosystem and innovation found in Linux
  - Red Hat OpenShift on Z enables hybrid cloud deployment
  - Virtualization allows co-location of Linux and z/OS
  - z/OS Container Extensions run Linux containers under z/OS
  - LinuxONE model optimized to run Linux-only workloads

Linux on IBM Z and LinuxONE

- Application Development for Linux on IBM Z
  - Most Linux applications can simply be recompiled to run on IBM Z
    - Assuming a compiler / development environment is available
  - Large suite of development environments supported, including
    - GNU Linux system toolchain: GNU compiler collection, GNU binutils, GNU debugger, etc. (C, C++, Fortran, Ada, …)
    - LLVM suite: clang (C, C++); Rust; Swift; MLIR; LLDB; …
    - Go
    - Java (IBM JDK & OpenJDK)
    - JavaScript & node.js; WebAssembly (various implementations)
    - Python; Perl; Ruby; PHP; …
  - One major missing language ecosystem *until now*: .NET

Porting .NET 6 to IBM Z

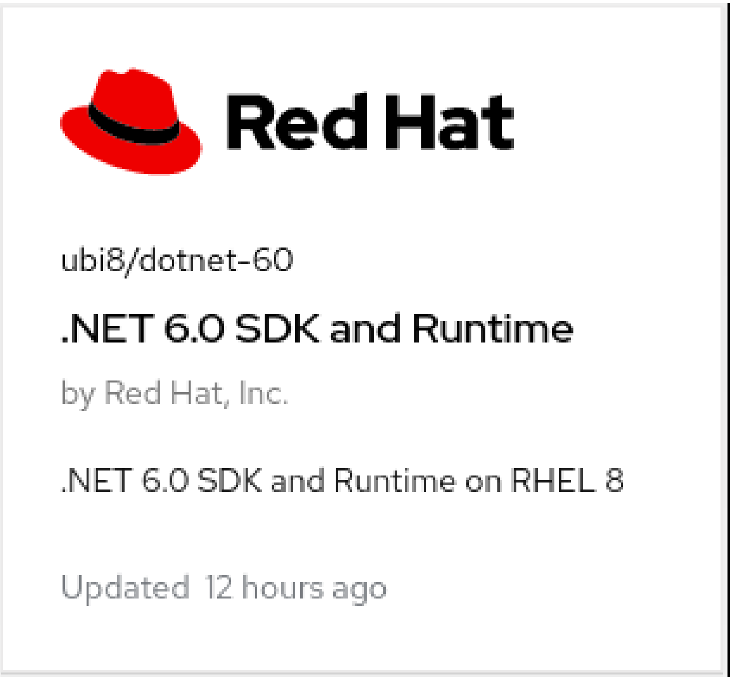
- History of .NET on Z
  - .NET Framework, .NET Core, .NET 5 – no IBM Z support
  - Mono has been supported on IBM Z since 2007
- What are the core .NET 6 components?
  - Runtime (VM & JIT) – CoreCLR and Mono variants
  - Base class libraries
  - SDK (C#, VB, F# compilers; tools like msbuild, nuget)
  - ASP.NET Core
- What components require porting?
  - Runtime: major effort (JIT generates machine code!)
  - Other components: minor / no changes required

Porting .NET 6 to IBM Z

- What is the current status of the IBM Z port?
  - IBM Z fully supported throughout all .NET core components
    - Uses the Mono runtime variant
    - Community-supported platform
  - All changes upstream in https://github.com/dotnet
    - About 100 PRs submitted, reviewed, and merged
    - Changes include enhancements to the IBM Z Mono back-end (fixes, performance enhancements), big-endian enablement in various components, and integration into the upstream CI
  - Collaborative effort by IBM, Red Hat, Microsoft, and the .NET and Mono open-source communities – thanks for your support!

.NET on RHEL and OpenShift

- Red Hat and Microsoft announced a partnership in Nov 2015 to bring .NET to Red Hat
- .NET supported on both Red Hat Enterprise Linux and Red Hat OpenShift Container Platform
  - .NET 6.0 is included in the AppStream repositories for RHEL 8.5
  - Use the ubi8/dotnet-60-runtime image to run a precompiled application inside a Linux container. The ubi/dotnet-60 image contains both runtime and SDK and can be used to build applications.
  - .NET images are added to OpenShift by importing imagestream definitions from s2i-dotnetcore.
  - `https://github.com/redhat-developer/s2i-dotnetcore`
- Platforms: Intel, ARM64 (new), IBM Z (new)



ubi8/dotnet-60

.NET 6.0 SDK and Runtime

by Red Hat, Inc.

.NET 6.0 SDK and Runtime on RHEL 8

Updated 12 hours ago

Demo

Demo

```
[uweigand@m3545017 ~]$ dotnet --info
.NET SDK (reflecting any global.json):
 Version:   6.0.100
 Commit:    9e8b04bbff

Runtime Environment:
 OS Name:     rhel
 OS Version:  8
 OS Platform: Linux
 RID:         rhel.8-s390x
 Base Path:   /usr/lib64/dotnet/sdk/6.0.100/

Host (useful for support):
  Version: 6.0.0
  Commit:  4822e3c3aa
```

```
.NET SDKs installed:
  6.0.100 [/usr/lib64/dotnet/sdk]

.NET runtimes installed:
  Microsoft.AspNetCore.App 6.0.0
[/usr/lib64/dotnet/shared/Microsoft.AspNetCore.App]
  Microsoft.NETCore.App 6.0.0
[/usr/lib64/dotnet/shared/Microsoft.NETCore.App]

To install additional .NET runtimes or SDKs:
  https://aka.ms/dotnet-download
```

Porting .NET applications to IBM Z

- Steps to ensure your application will run on IBM Z
  - If not already done, port to .NET 6
  - Ensure the application runs on Linux (avoid using Windows-specific frameworks / assemblies)
  - Fix platform-specific managed code constructs, if any
    - E.g. use of `System.Runtime.InteropServices.Architecture`
    - Endian-specific data accesses like `BitConverter.ToInt32`
  - If applicable, port native (e.g. C/C++) components
  - Make sure third-party dependencies are available

Porting .NET applications to IBM Z

- Resources available to ISVs / open-source projects
  - IBM LinuxONE Community Cloud
    - https://developer.ibm.com/gettingstarted/ibm-linuxone/
    - The IBM LinuxONE Community Cloud is a no-charge, 24 x 7, enterprise-grade, open access, shared public cloud environment on IBM's LinuxONE platform. Offered in collaboration with Marist College.
  - IBM LinuxONE Partner Network
    - https://www.ibm.com/partnerworld/systems/linuxone/isv-partner-ecosystem
    - Join the IBM LinuxONE Partner Network to deliver innovative solutions with speed and scale, and get access to an array of benefits and resource.
  - IBM Cloud Hyper Protect Virtual Servers
    - https://www.ibm.com/cloud/hyper-protect-virtual-servers
    - IBM Cloud® Hyper Protect Virtual Servers provide complete authority over workloads with sensitive data within a secure virtual server environment.   Powered by IBM LinuxONE.

RELEASED

Nov 9th: Red Hat .NET 6.0 on IBM Z (s390x)

- .NET 6.0 RPM packages in Red Hat Enterprise Linux 8.5
- .NET 6.0 runtime & SDK UBI container images

https://developers.redhat.com/products/dotnet/overview

If you are interested in

- running .NET workloads on IBM Z; or
- porting your ISV / open-source .NET application to IBM Z

please reach out to us!

Thanks for joining!