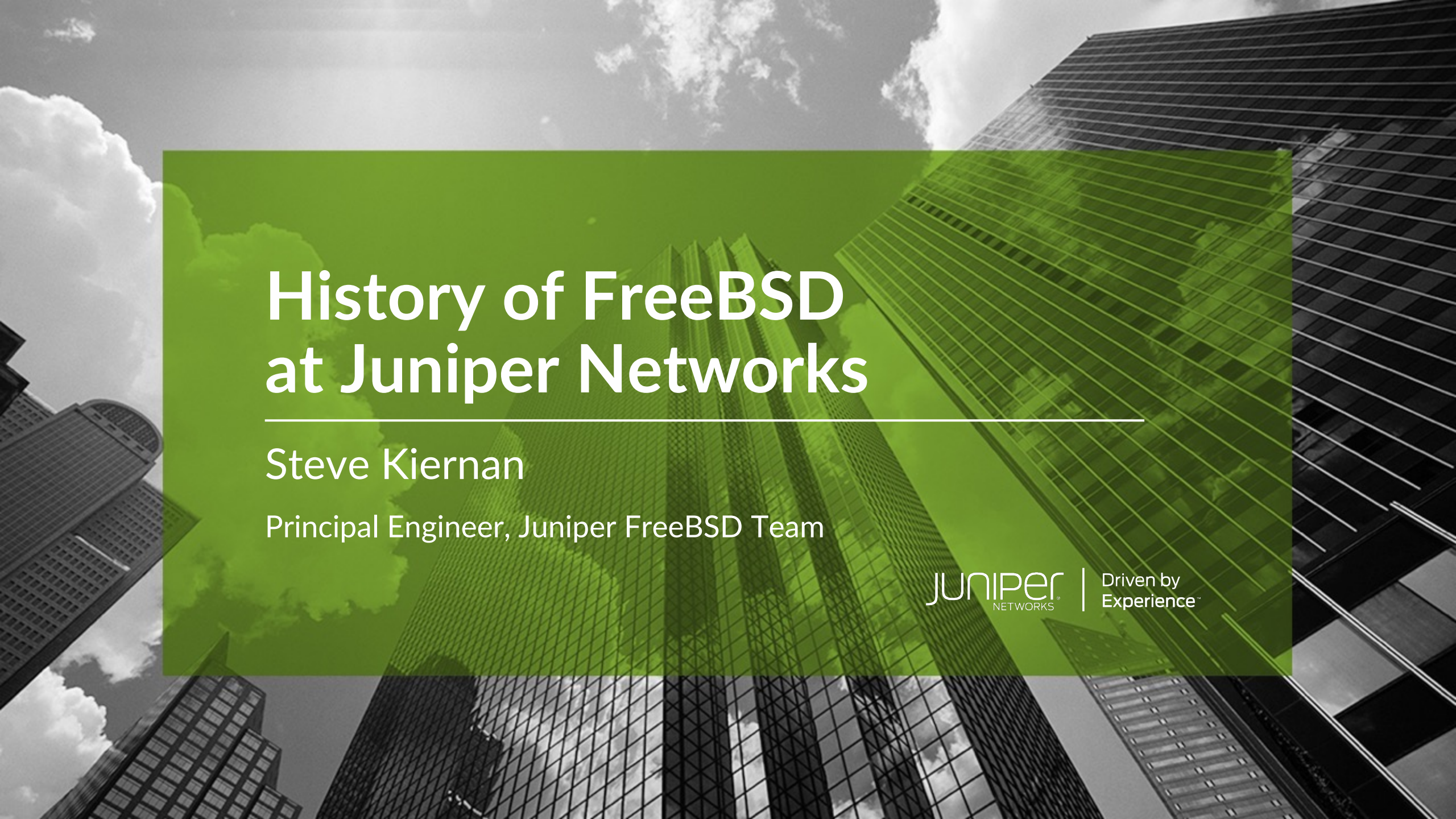

History of FreeBSD at Juniper Networks

Steve Kiernan

Principal Engineer, Juniper FreeBSD Team

JUNIPER NETWORKS | Driven by Experience™

Agenda

Timeline

The Early Years

Freeway

Turnpike

Autobahn

Occam

Obelix

Current Plans

Timeline

25 Years of Juniper

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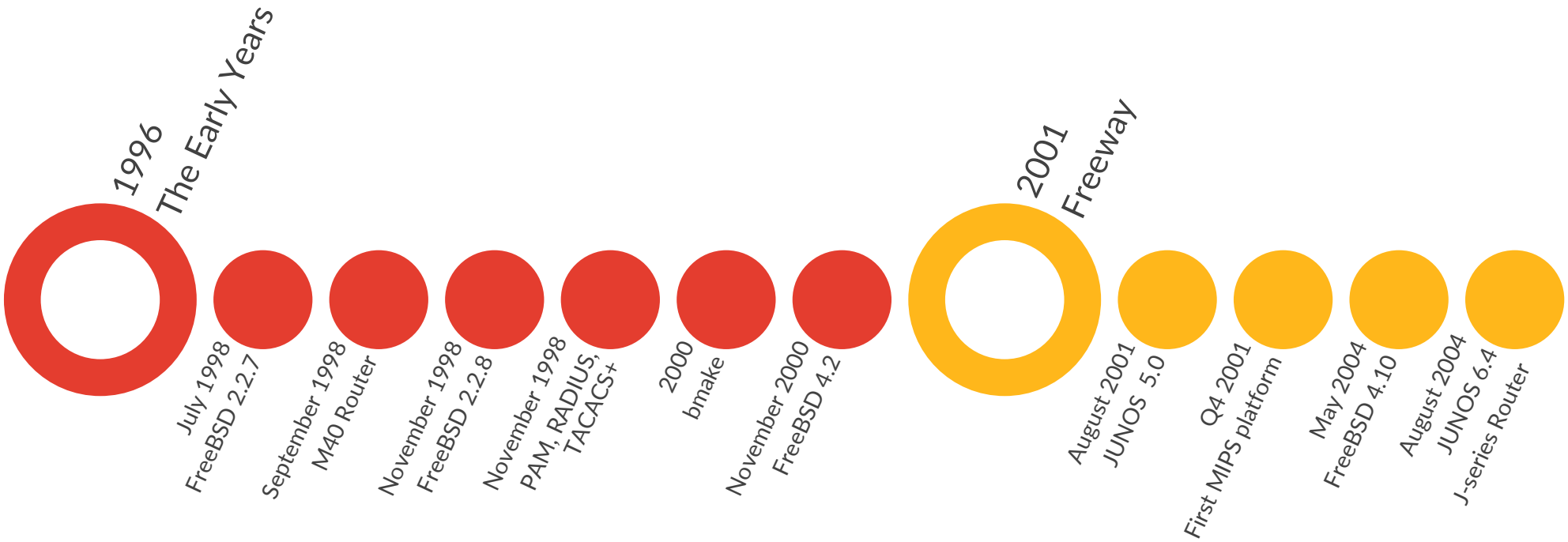
Timeline



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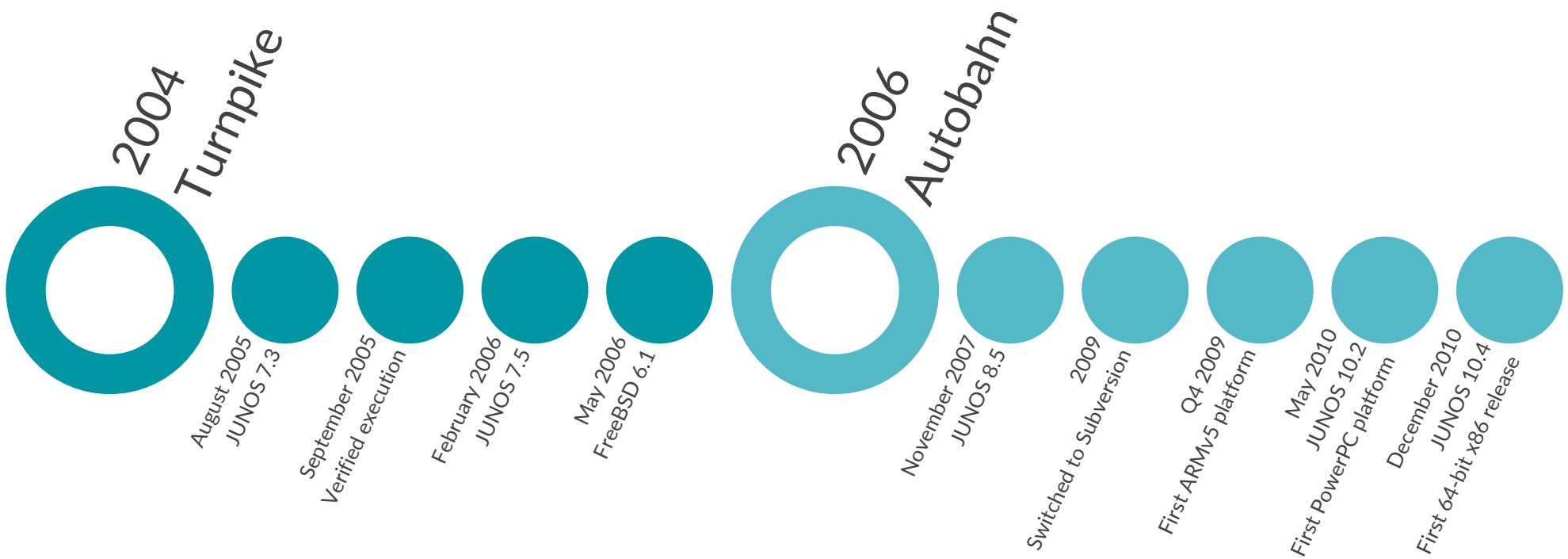
Timeline



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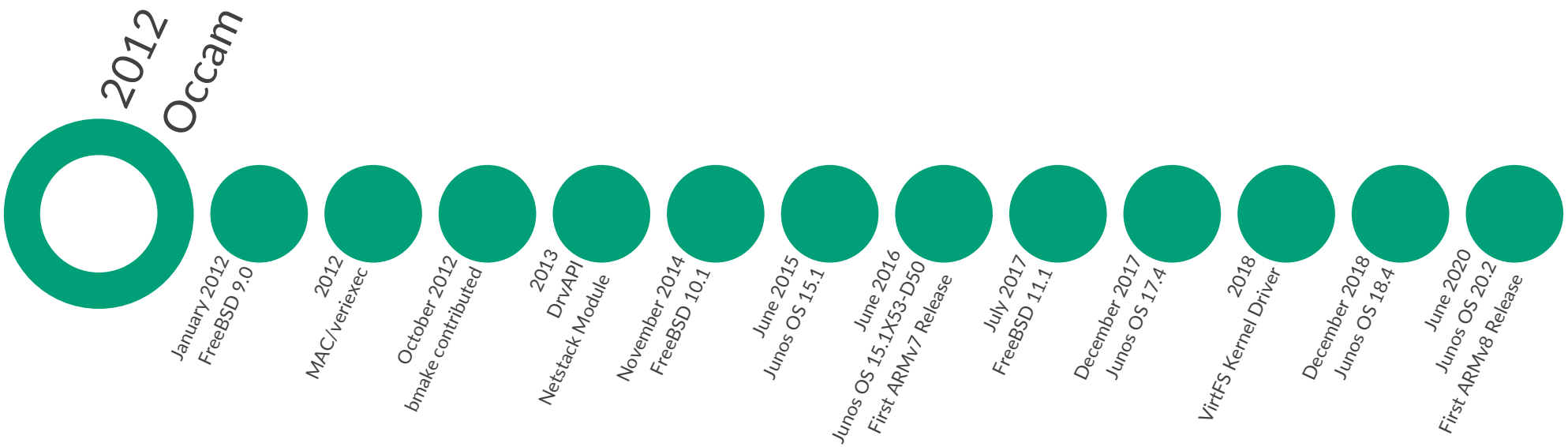
Timeline



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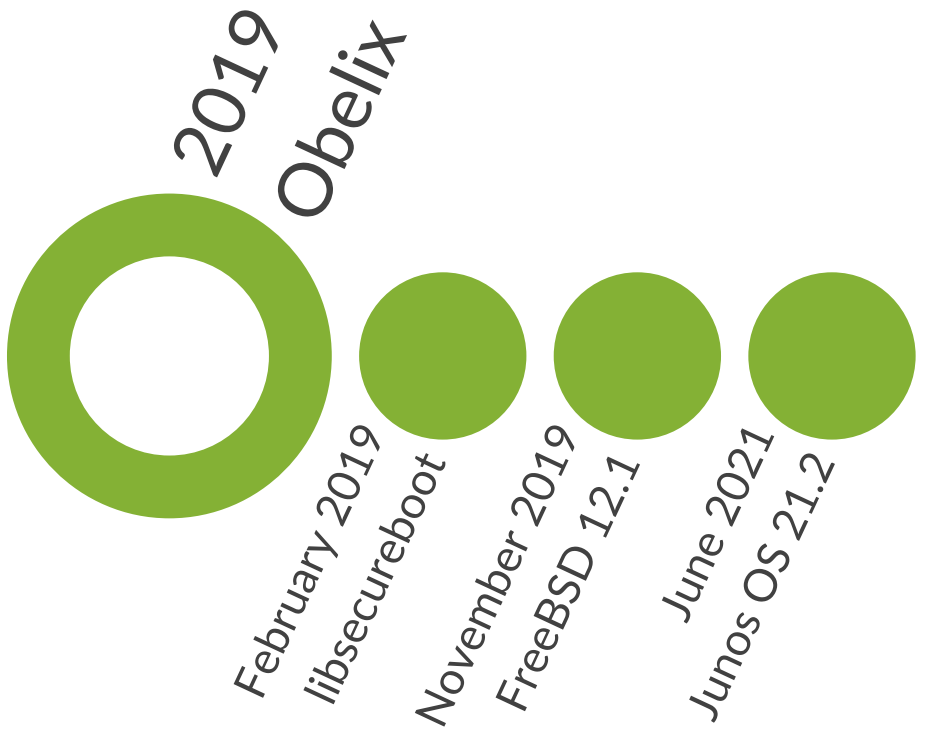
Timeline



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The Early Years

1996

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The Early Years

- First release shipped based on FreeBSD 2.2.7
- JUNOS was two packages (jkernel and jroute) installed on top of FreeBSD
  - JUNOS CLI as the login shell
  - 32-bit x86 (i386) CPU supported
- First shipping product – M40 router (September 1998)
- Moved to FreeBSD 2.2.8 shortly after it was released
- bmake used for building (2000)
  - Integrated into upstream FreeBSD in 2012 (more about this later)

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The Early Years

- Contributions to FreeBSD
  - Pluggable Authentication Modules (PAM) support (November 1998)
    - RADIUS and TACACS+ libraries
  - GDB remote debug protocol

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Freeway

2001

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Freeway

- Project to upgrade to FreeBSD 4.2
- Released in JUNOS 5.0 (August 2001)
- Introduction of compressed ISO-9660 filesystem for packages
  - Package scripting used FreeBSD package format (+INSTALL, +DEINSTALL, etc.)
  - Contents of ISO images were dictated by manifest files
- TCP/IP network code remained on FreeBSD 2.2.8 version

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Freeway

- First MIPS platform supported in Q4 2001
  - RM7000A MIPS processor
  - CPU support ported from NetBSD and OpenBSD sources
- J-Series Router in JUNOS 6.4 (August 2004)
  - RT-LINUX core support

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Turnpike

2004

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Turnpike

- Project to upgrade to FreeBSD 4.10
- Released in JUNOS 7.3 (August 2005)
- TCP/IP network code updated to 4.10

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Turnpike

- Verified execution (September 2005)
  - Originally obtained from NetBSD
  - Only allows running binaries or opening files that match fingerprint (hash) in kernel database
  - Many changes since
    - O_VERIFY flag
    - Verified file system support

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Autobahn

2006

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Autobahn

- Project to upgrade to FreeBSD 6.1
- Released in JUNOS 8.5 (November 2007)
- Giant lock needed in many parts of the code
- spl usage in JUNOS network stack replaced with locks where necessary

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Autobahn

- In 2009, Juniper switched from CVS to Subversion for source control management
- JUNOS 10.1 released February 2010
  - First ARMv5 platform supported
- JUNOS 10.2 released May 2010
  - First PowerPC BookE (e500) platform supported
- JUNOS 10.4 released December 2010
  - First 64-bit x86 release

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Autobahn

- Contributions to FreeBSD
  - 32-bit PowerPC kernel core file support for libkvm
  - MIPS support for gprof, thread debugging
  - Kernel profiling for PowerPC (AIM and BookE)
  - cfi(4) driver
  - Minidump support
    - 32-bit ARM (Semihalf contracted)
    - PowerPC
  - gdbserver support for ARM and PowerPC
  - FPA floating-point format on ARM
  - netisr(9) statistics in netstat(1) (sponsored development)
  - Network stack parallelism improvements (sponsored development)
  - Core file enhancements
    - Compressed cores, EVENTHANDLERs, additional format patterns
  - Makefs improvements
  - NANDFS (sponsored development)
  - filemon(4) device driver

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Occam

2011

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Occam

- At the time of planning for the Occam project…
  - JUNOS supported arm, i386, mips, and powerpc MACHINE types
    - At least 4 variants of MIPS
    - At least 2 variants of PowerPC
  - Many different packages to handle the various platforms
  - SMP was mostly not supported
  - Many modifications to FreeBSD code over the years made upgrades take longer and longer
- Some pieces of code from FreeBSD 6.2 and above were cherry-picked back to into JUNOS
- Changes were necessary
  - Make upgrading easier
  - Contributing code changes back to upstream with less chance of conflicts or requiring entire rewrites

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Occam

- Project to re-implement Junos OS on top of a pristine and current version of FreeBSD
  - FreeBSD version provided as a pre-published component
  - FreeBSD sources in separate repository from the rest of the Junos OS sources
  - Implemented in stages
    - Physical separation of FreeBSD sources from the rest of Junos OS sources
    - Logical separation to establish useful interfaces
  - SMP support on multi-core routing engines (RE-S-1800x2 and RE-S-1800x4 initially)
  - Giant lock previously used by parts of Junos OS code replaced with finer grained locks
- Released in JUNOS 15.1 (June 2015)
- Initially started with FreeBSD 9-CURRENT, shipping version was FreeBSD stable/10 (nearly equivalent to 10.1-RELEASE)
- Only 32-bit and 64-bit x86 CPUs initially supported

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Occam

- ARMv7 support shipped in Junos OS 15.1X53-D50.2 release (June 2016)
  - EX2300 and EX3400 switches
  - FreeBSD 11-CURRENT based
  - Integrated into mainline in Junos OS 18.1
- ARMv8 support shipped in Junos OS 20.2 release (June 2020)
  - Required back port of arm64 machdep code from head to stable/11
- VirtFS Kernel Driver (2018)
  - Plan 9 file system (9PFS) support as a virtual file system kernel driver
- Junos OS 18.4 (December 2018)
  - Support for AWS (KVM and Xen), Azure (Hyper-V), Google Cloud, Vmware

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Occam

- Contributions to FreeBSD
  - DrvAPI
    - Procedural interface to the ifnet structure
  - MAC/veriexec module
  - Network stack as module
    - Reviews posted to Phabricator in 2016, updating and re-submiting for reviews in early 2022
    - Presentation at BSDCan 2016 – Transport Working Group Session - stevek
  - bmake
    - Meta mode support
    - Presentation at BSDCan 2014 – sjg
  - Loader changes
    - pkgfs support (install command)
  - libxo(3) library
  - HWPMC optimizations
  - Per-thread HWPMC support (early version contributed, updates in progress)
  - ARM hardware watchpoints (sponsored development)

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Obelix

2019

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Obelix

- Upgrade to stable/12 shipped in Junos OS 21.2 (June 2021)
  - i386, amd64, arm, arm64 MACHINE types supported
  - Upgrade to LLVM 9.0 (LLVM 10.0 in Junos OS 21.4)
  - Support for more than 40 Juniper platforms (routing, switching, access, security)
  - Junos network stack switched from legacy TX to multiqueue
  - Number of changes required due to iflib
- Verified execution loader (veloader)
  - Extends veriexec functionality to the loader
  - libsecureboot contributed to FreeBSD
- Octeon 64-bit support (2021)

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Obelix

- Contributions to FreeBSD
  - KVMCLOCK driver with vDSO support (sponsored development)
  - VirtFS kernel support (in progress)
  - Live core dump (sponsored development, in progress)

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Current Plans

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Current Plans

- Continuous integration of FreeBSD main branch
  - Periodic sync from upstream Git repo
  - Automated build and testing
  - Addition of test cases for OS stability
- FreeBSD stable/13 upgrade
- Kernel debugger security improvements
- Debugger Python scripts (gdb and lldb)
- Kernel sanitizers for ARM
- VirtIO visibility tools
- Scheduler visibility tools
- Maintain Forth loader

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Thank you
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