OS Security

Virtualization

Radboud University, Nijmegen, The Netherlands

Winter 2017/2018

A peek into 2018

- January 9, hoorcollege: Q&A (exam preparation)
- January 11, werkcollege: presentation of last homework
- January 16, hoorcollege: guest lecture

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- Example of OS virtualization: Linux containers (LXC)
- Main concepts of LXC:
  - namespaces (restrict what a container can see)
  - cgroups (manage resource sharing between containers)

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- Run multiple environments in parallel
- Example: Development Debian system in `chroot` on Android phone

OS-level virtualization for security?

Relationship status: it's complicated

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Additional limitations

- Cannot use containers for testing different OS
- Container snapshots exclude the kernel
- Container snapshots exclude memory content

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- Disadvantage: serious performance penalty

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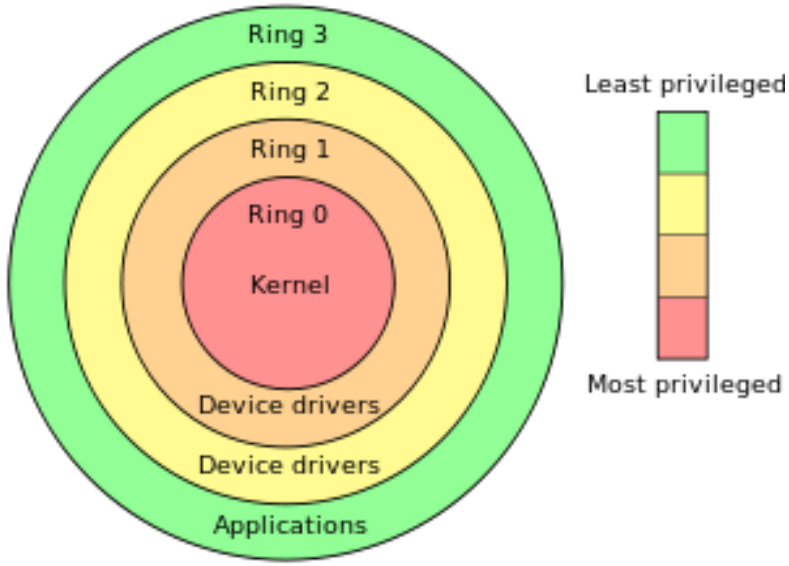

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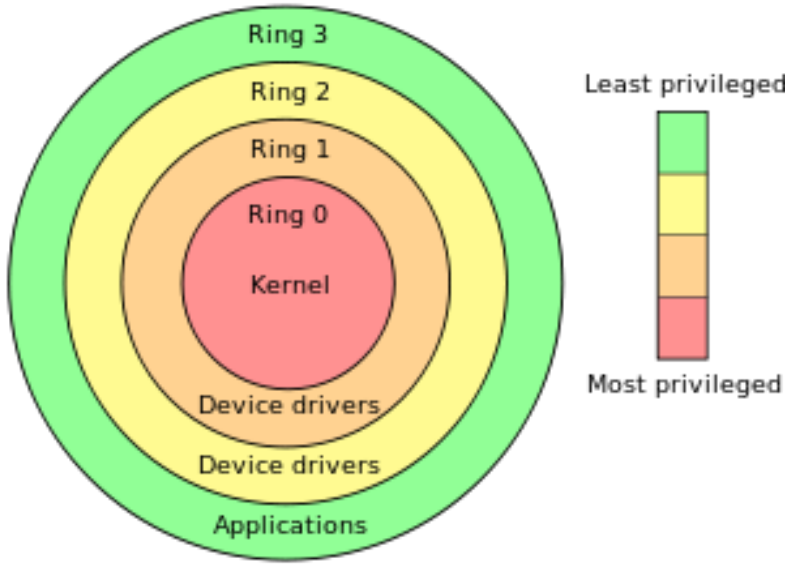
- Idea: run VMM in ring 0, guest OS in ring 1



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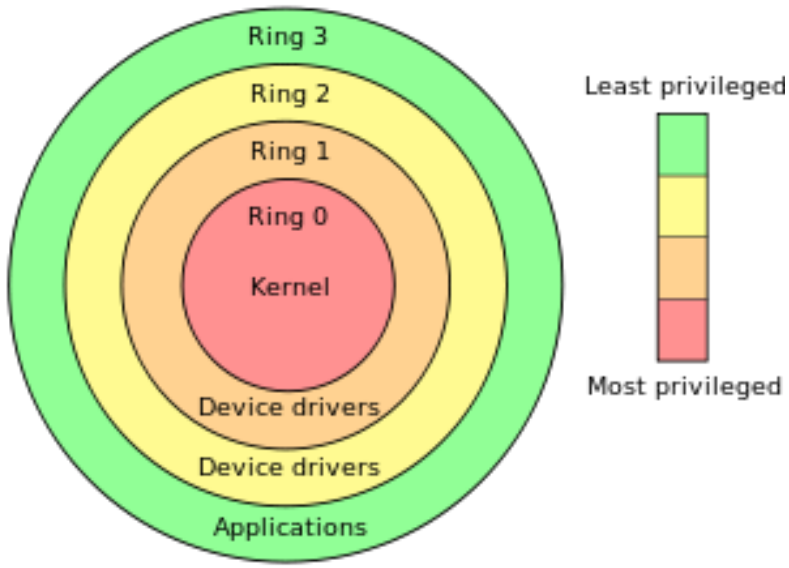

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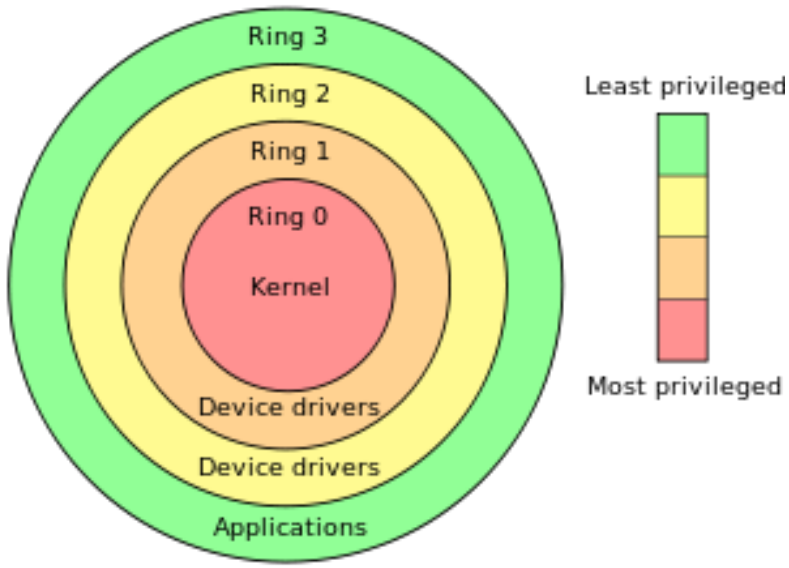
- This concept of virtualization using modified guest OS is called **paravirtualization**
- Linux has support for paravirtualization since 2.6.23 (`pv-ops`)



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- Question: can we *fully virtualize* machines?
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- Run everything natively, except ring-0 instructions
- Translate ring-0 instructions on the fly (similar to emulation)

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  - ARM Virtualization Extensions (VE)
- Modern implementations also include hardware memory virtualization
- Multiple hypervisors for x86/AMD64 hardware virtualization, e.g., VMWare Workstation, Linux KVM, Xen

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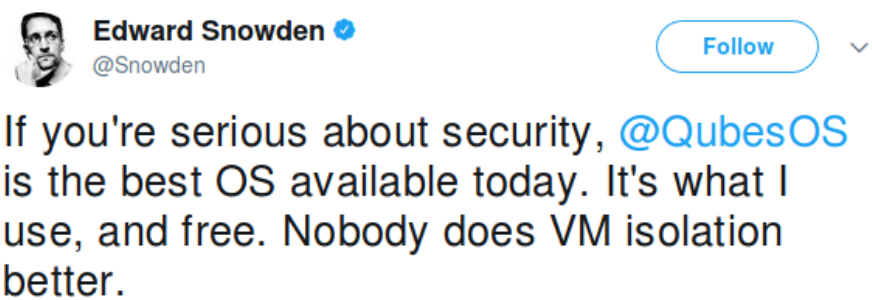
- Solution: I/O Virtualization
- Assign I/O devices to VMs
- Use input-output memory management unit (IOMMU) for DMA
- Examples: Intel VT-d, AMD-Vi

Qubes OS

- Desktop (mainly laptop) operating system building on Xen
- Developed by Invisible Things Lab (ITL, founded by Joanna Rutkovska)
- Builds on Xen
- Dom0 is running Fedora Linux
- Multiple tools to integrate working with VMs



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- Can make changes to AppVMs persistent (but not stealthily so)

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- Solution:
  - Standalone VMs that have their own root-file-system copy
  - Hardware VMs (also standalone) to support, e.g., Windows
  - Use Qubes Windows tools for integration with other VMs

Separation by security domains

- Create different AppVMs for different tasks or roles
- Example:
  - AppVM for e-mail
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  - AppVM for banking
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- That's even with full root access to the Skype AppVM!
- Consequence: No root password by default

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- Can copy-paste via Qubes clipboard
  - Copy from local clipboard of source VM by CTRL-Shift-C,
  - Paste into local clipboard of destination VM by CTRL-Shift-V
  - Pasting from global clipboard will clear contents

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- You save the document, close LibreOffice and all changes are lost!

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"If you have two GUI applications, e.g. an OpenOffice Word Processor, and a stupid Tetris game, both of which granted access to your screen (your X server), then there is no isolation between those two apps. Even if they run as different user accounts! Even if they are somehow sandboxed by SELinux or whatever! None, zero, null, nil!"

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"The X server architecture, designed long time ago by some happy hippies who just thought all the ~~people~~ apps are good and non-malicious, simply allows any GUI application to control any other one. No bugs, no exploits, no tricks, are required. This is all by design. One application can sniff or inject keystrokes to another one, can take snapshots of the screen occupied by windows belonging to another one, etc."

—Joanna Rutkovska

https://blog.invisiblethings.org/2011/04/23/linux-security-circus-on-gui-isolation.html

GUI separation

- Why would you go through the hassle of using Qubes?
- Maybe the best answer: **GUI separation**
- In Linux, under X, every program can read and write mouse and keyboard input to all other programs!
- Wait, what?!

Easy demo

- Simply run `xeyes` from the `x11-apps` package
- Run `xinput test-xi2 -root`
- Simply run `gnome-screenshot` (or other screenshot program)

Full screen

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- Examples:
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  - Pretend to crash and fake other application's input (e.g., browser with Facebook login page)
- Qubes' colored frame *always* makes clear in what VM you are
- Can enable full-screen through AppVM configuration in dom0

Networking

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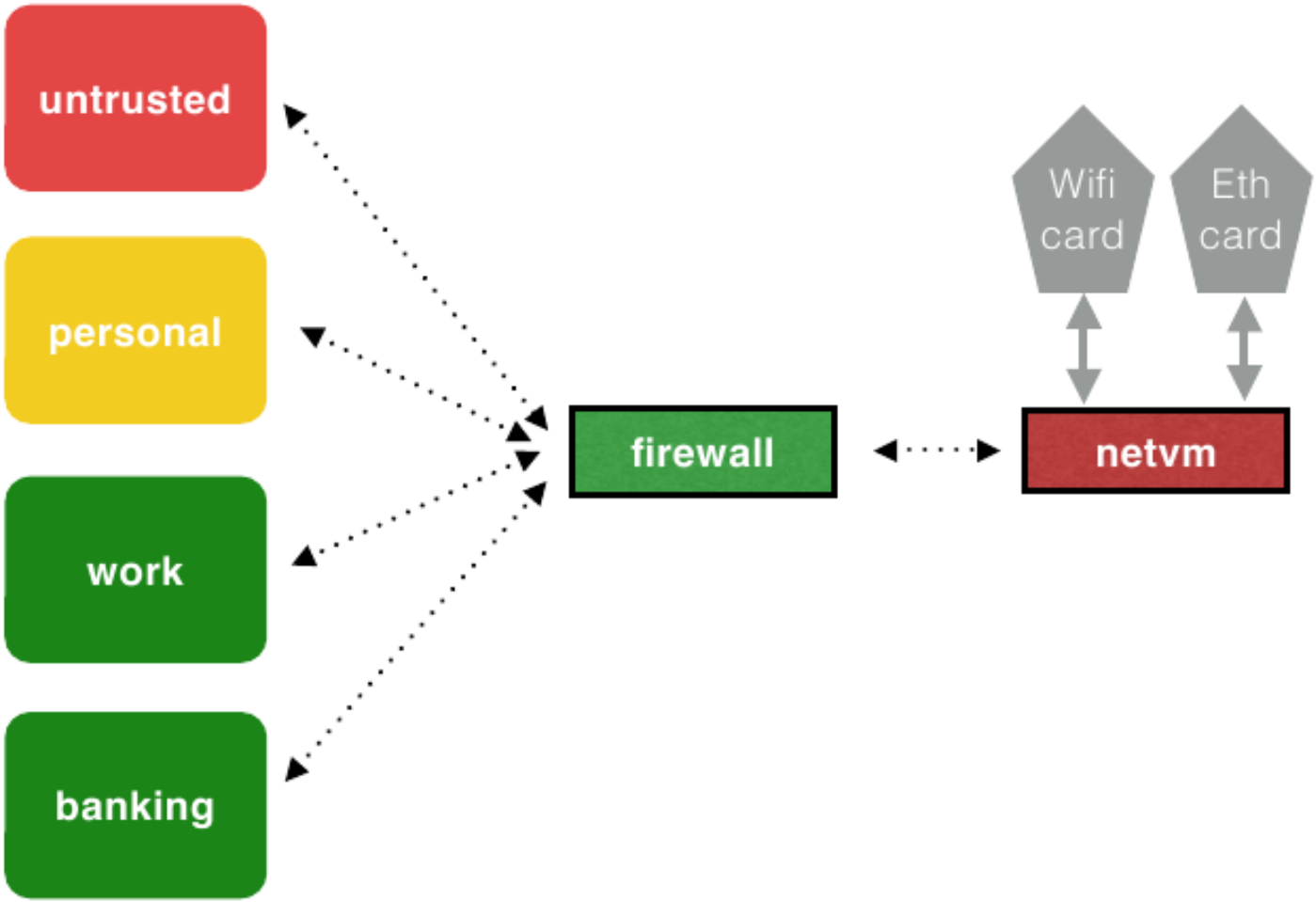
Networking



https://theinvisiblethings.blogspot.nl/2011/09/playing-with-qubes-networking-for-fun.html

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- Firewall rules for AppVMs are stored in dom0, provided to and enforced by `sys-firewall`
- Ideally limit network access of trusted AppVMs
- Examples:
  - `mail` VM only has access to SMTP and IMAP server
  - `research` VM only has access to some git servers
  - `shopping` VM only allows HTTPS

USB

USB

- Would you plug a USB stick somebody gives you into your laptop?
- Generally a large security risk; used to compromise air-gapped systems in the real world!
  https://www.youtube.com/watch?v=ZI5fvU5QKwQ

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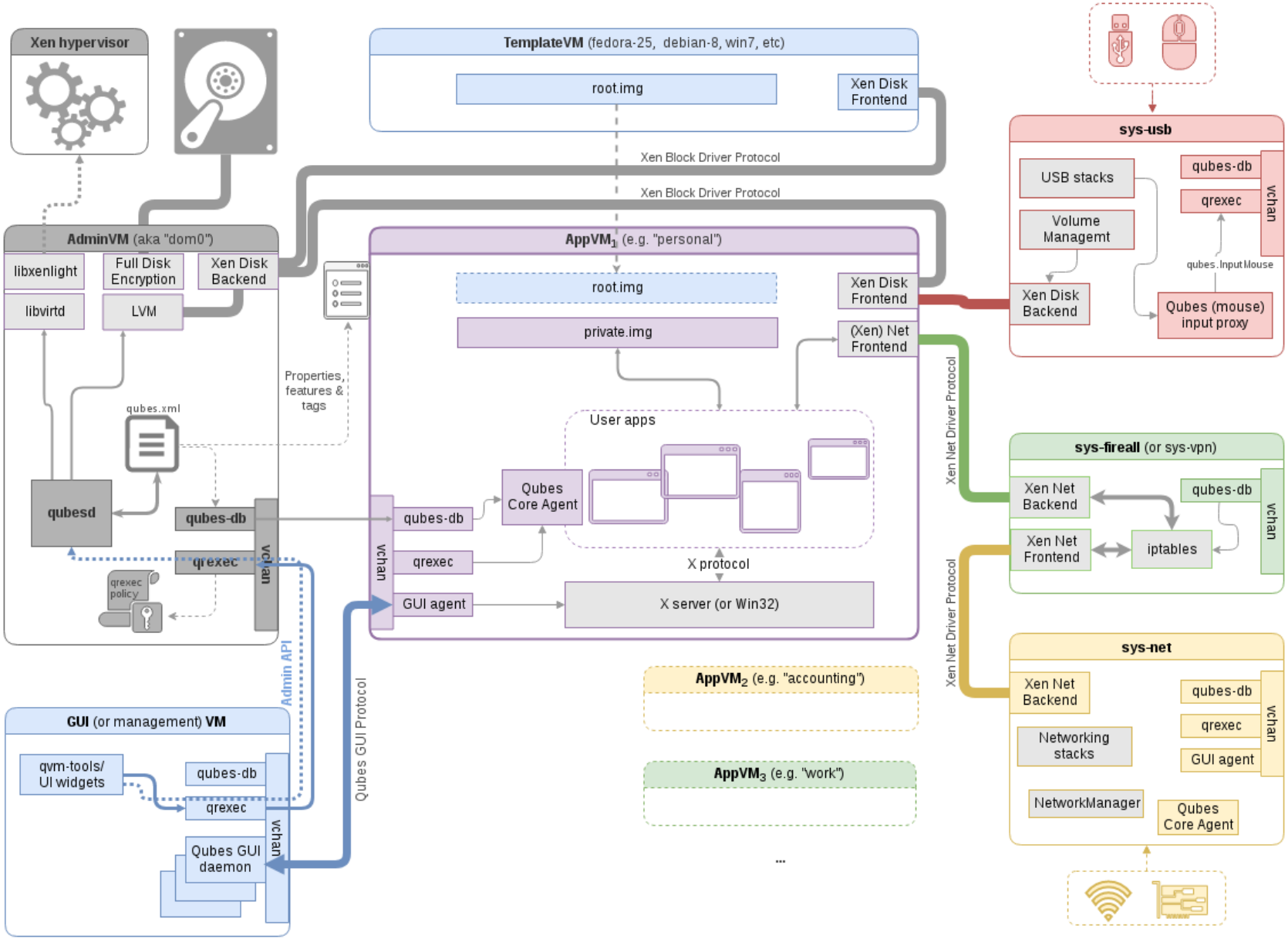
- Disadvantages:
  - Slightly more effort to copy files to USB stick
  - No USB input devices in other VMS


Xen hypervisor
TemplateVM (fedora-25, debian-8, win7, etc)
root.img
Xen Disk Frontend
Xen Block Driver Protocol
Xen Block Driver Protocol
sys-usb
USB stacks
Volume Managemt
qubes-db
qrexec
vchan
qubes.InputMouse
Xen Disk Backend
Qubes (mouse) input proxy
AdminVM (aka "dom0")
libxenlight
Full Disk Encryption
Xen Disk Backend
libvirtd
LVM
AppVM1 (e.g. "personal")
root.img
private.img
Xen Disk Frontend
(Xen) Net Frontend
Properties, features & tags
qubes.xml
User apps
qubesd
qubes-db
qrexec
vchan
qrexec policy
Qubes Core Agent
X protocol
GUI agent
X server (or Win32)
Xen Net Driver Protocol
sys-firewall (or sys-vpn)
Xen Net Backend
Xen Net Frontend
qubes-db
iptables
vchan
Xen Net Driver Protocol
sys-net
Xen Net Backend
Networking stacks
NetworkManager
qubes-db
qrexec
GUI agent
Qubes Core Agent
vchan
AppVM2 (e.g. "accounting")
AppVM3 (e.g. "work")
...
Admin API
Qubes GUI Protocol
GUI (or management) VM
qvm-tools/ UI widgets
qubes-db
qrexec
Qubes GUI daemon
vchan

Qubes and GPG

- `mail` VM needs access to GPG keys
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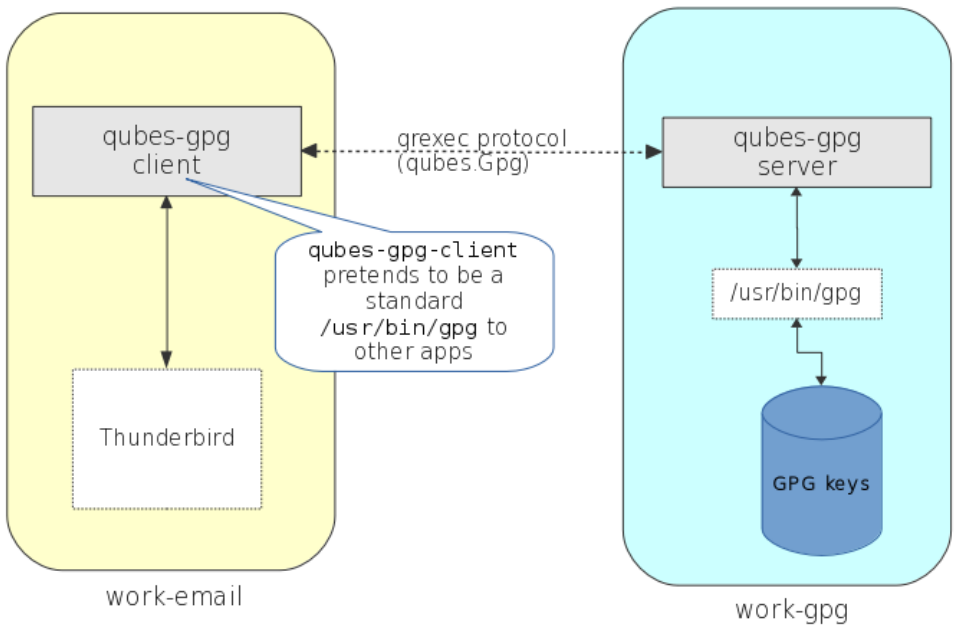
- Idea: simulate a smartcard in a trusted VM (no network access)



https://www.qubes-os.org/doc/split-gpg/

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LILY HAY NEWMAN SECURITY 11.20.17 11:10 PM

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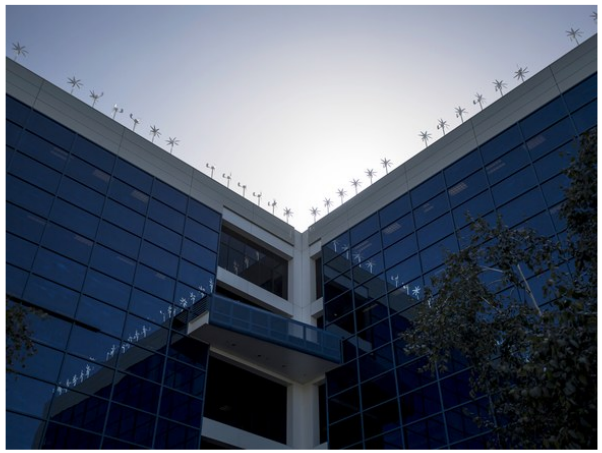

The Intel Corp. headquarters in Santa Clara, CA.

DAVID PAUL MORRIS/BLOOMBERG/GETTY IMAGES

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- Ideally: formally verify TCB
- Separate security domains (with corresponding data)
- Limit damage done by malicious non-TCB software


Prettige
Kerstdagen!