Using Chroot to Bring Linux Applications to Android

Getting the best of both worlds…

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What We'll Talk About…

- Why mix Android and Linux?
- Android under Linux
- Linux under Android
- Communicating between the domains

What are we trying to Accomplish?

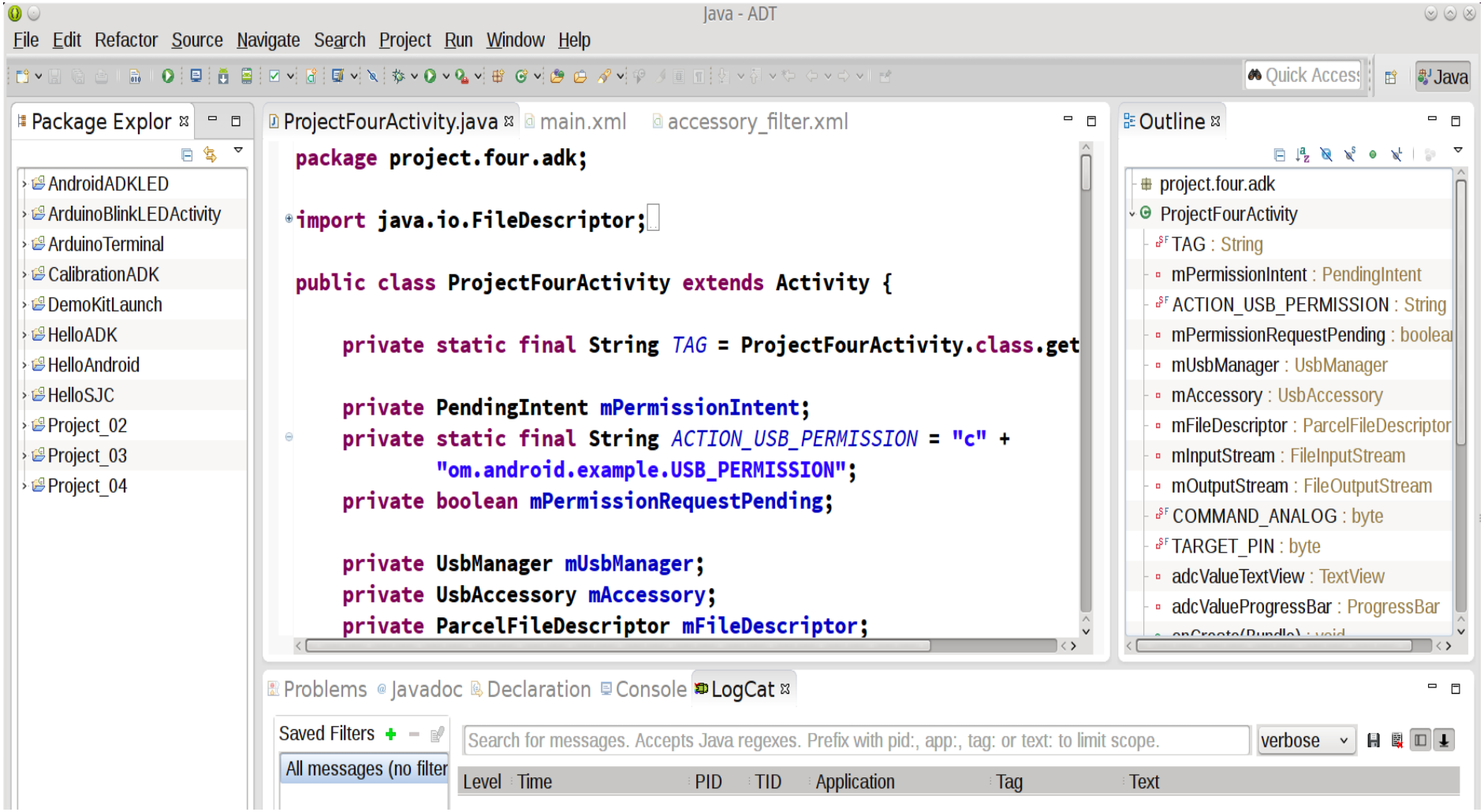
- Android is probably the most widely deployed version of Linux on the planet
  - We want to extend the platform to handle other tasks without extensive modification of the underlying framework
- Enable porting of Linux applications to Android
- Ease package management issues by allowing easy access to Linux repositories
- Get an optimal mix of Linux and Android for use in non-phone applications

Advantages of Android

- Tremendous market position
- Well-defined development and deployment environments
  - Great application framework with good modularity
    - Network, audio, power, etc.
- Well-understood GUI/UX
- Good selection of Java libraries
- Availability of NDK gives option for higher performance than Java implementation

Source: pctechmag.com

Good Integration of SDK



Disadvantages of Android

- Package management
  - Difficult to update the underlying framework
- Library and application availability
  - Purpose-built for phones/tablets and not much else
- Extensions to elements like libsensors requires rebuilding the AOSP sources
- GUI choice dictates the kernel choice
  - 4.1 is different from 4.4
    - Look and feel are different too
  - Difficult to go off the path set by Google
- Android SCM does not facilitate easy extensions by non-OHA folks

Bionic libc Compatibility Issues

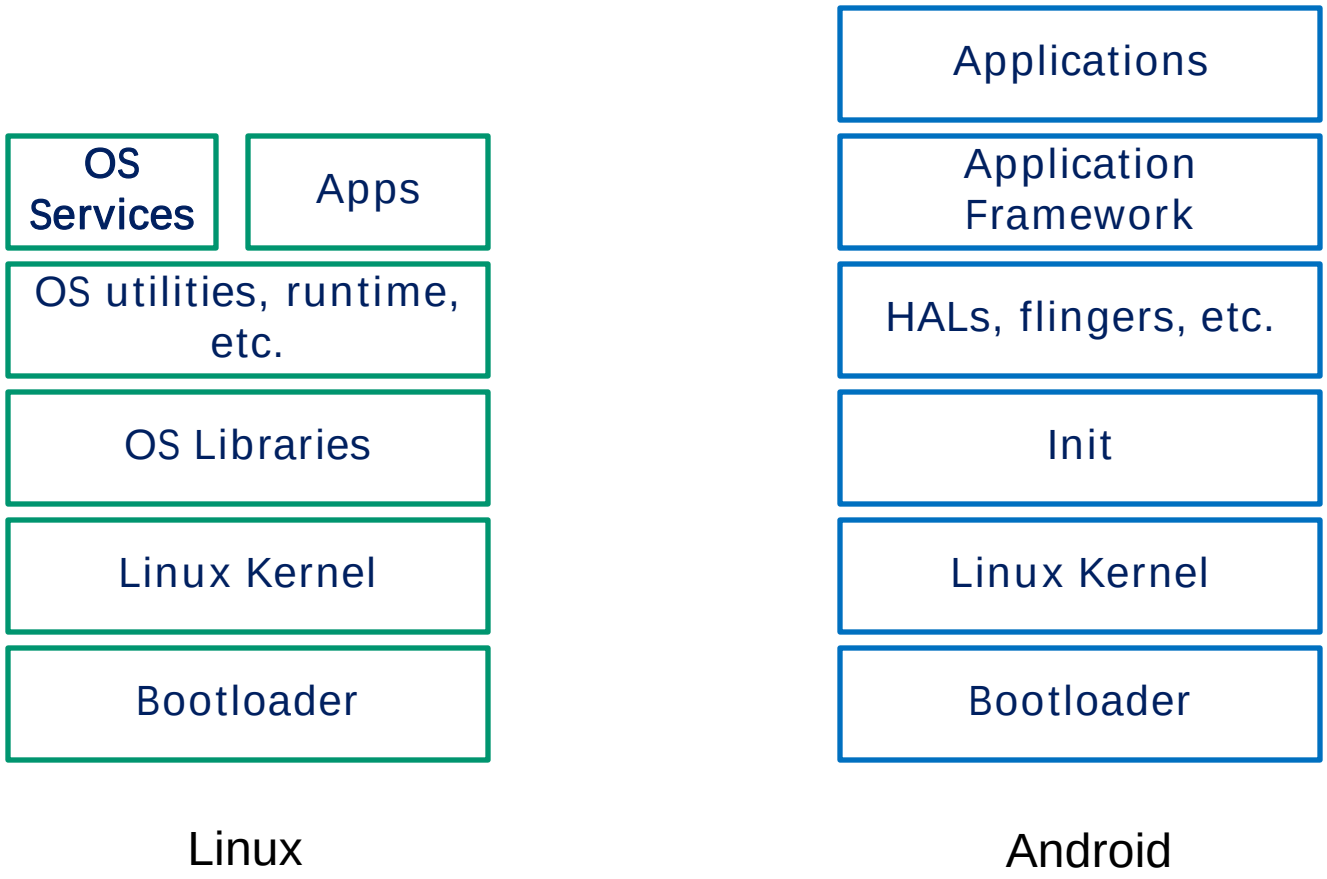
- Restricted POSIX compatibility
- No C++ exceptions
- No locales or wide char support

Source: slideshare.net

- Several missing functions like getpwd()
- Really built as a single-user user space
- More info found in bionic/libc/CAVEATS
- These issues and more make it difficult to port standard Linux applications to Android

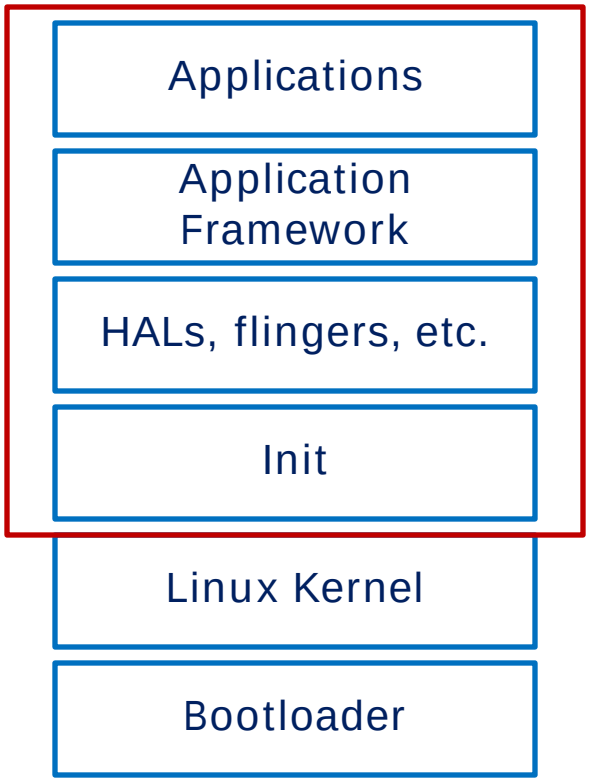
Different Views of the World

- Linux and Android see things differently



The Ideal World

- In the ideal world, we could just use the Android framework and get the UX
- Unfortunately, Android is a tightly-coupled architecture that makes that very difficult
- These elements need to be kept intact for Android to function



Several Approaches…

- If we want to run Linux code under Android, we could:
  1. Port the Linux code to bionic libc
     - Problematic due to differences between bionic and glibc
  2. Run Android as a package under Linux
     - The approach taken by Pragma**tux**
  3. **Run Linux applications in a chroot environment**
  4. **Extend LXC to support options 2 or 3 better**

What is “chroot”?

- Chroot is a command that was introduced into Unix in 1979
- Changes the apparent root file system for the calling process and its children
  - Used for development and testing when the target O/S release is different from the development host
- Once running in chroot, applications can’t typically get to files outside of the chroot
  - Often known as “chroot jail”
- Only root user can execute the chroot command

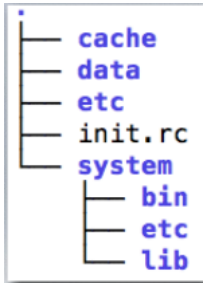
Source: bukisa.com

Pragmatux

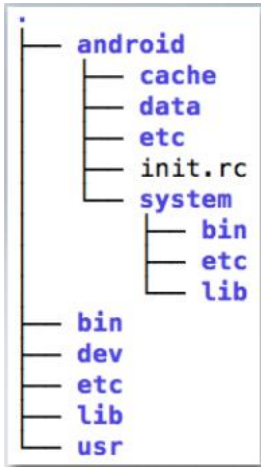
- Found at http://www.pragmatux.net/
  - Project leads are Bill Gatliff and Ryan Kuester
- Hardware boots Linux
  - Uses a Debian-like approach for repos
- Leverages idea that Android file system has little overlap with Linux file system
  - /proc, /etc, /dev, /sys are a few exceptions
    - Uses bind mounts to keep things straight
- Primary goal is to use Android framework for the UI but keep predictability of Linux for embedded applications

Android File System in chroot

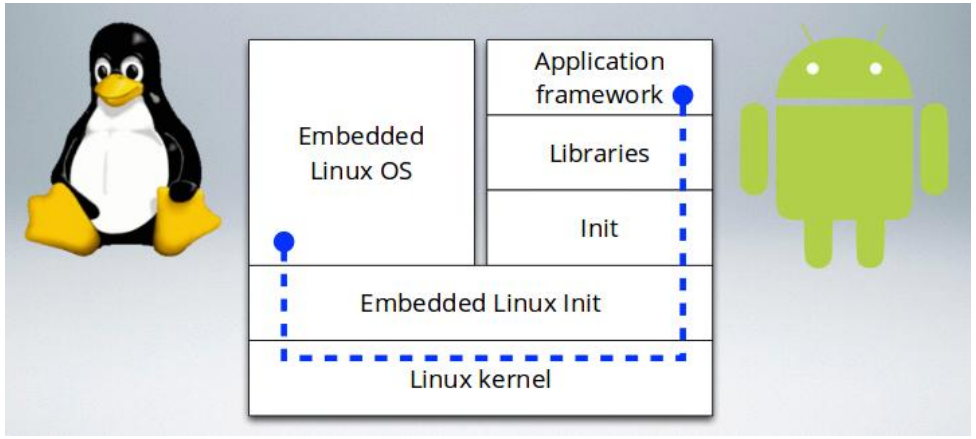
- We can encapsulate the Android environment into the embedded Linux file system
- Sockets and kernel communications work as normal



Android FS



Embedded FS



Source: insymbols.com

Communications Channels

+ / - of this Approach

- +
  - Linux is in charge and we can use modern kernel with PREEMPT_RT and Android code from staging tree for Android support
  - Gives us Android UX with HRT/SRT support for control applications
    - We can prioritize Android apps as needed
  - Helps keep costs down
    - Only one CPU needed
      - Multi-core is a big plus
- -
  - We need to tweak the Android init sequence so Android doesn't take over the device
    - We need to do the bind mounts as well
  - Complexity can be troublesome
  - We need enough RAM and storage for 2 O/S user spaces

Linux File System with chroot

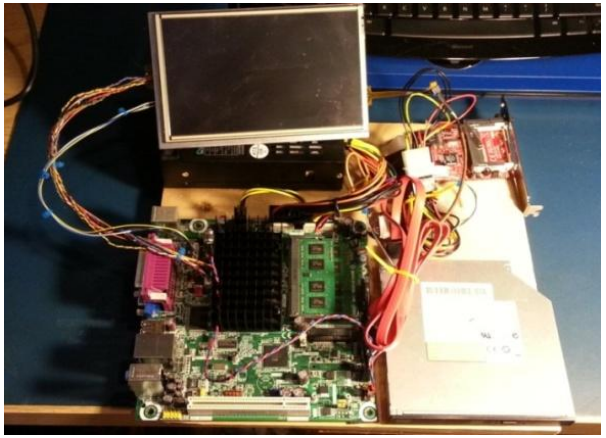
- An alternate approach is to host the Linux file system in the Android F/S
- The Android device must be rooted for this approach to work
- Using chroot, we can create an alternate root file system that Linux applications can live in easily
- Linux can live with /bin, /etc, /dev, /lib
  - /proc and /sys can be bind mounted
- Alternatively, we can loop mount an image and chroot to the mounted image
  - Gives us a full Linux in our Android

+ / - of this Approach

- +
  - There are already apps on Google Play that streamline this sort of installation
  - We get Linux package management capabilities
  - You can use VNC to get GUI-centric Linux applications running
  - Only one CPU needed
    - Multi-core is a big plus
  - We only need to install the libraries and minimum files to run
- -
  - RAM and storage requirements vary depending on applications being run
  - Android framework is in charge
  - Not likely that the kernel will have PREEMPT_RT or other latency settings
  - Development environment can be tricky
    - It's possible to install development environment on Android platform in chroot

Simple Example

- We had a customer that needed to run some RedHat-based programs, but wanted to get the Android UX
  - Media-scanning kiosk device
    - Looking for malware on user media
  - Cut down on training time for users and get touch-screen support
  - Developers were mostly Java centric
- We constructed an Android x86 platform running Atom using a COTS motherboard
- Built Android from AOSP sources and edited libsensors for the devices we had on the motherboard



Simple Example #2

- Using ldd we were able to isolate the application and required libraries to the bare minimum
  - Installed chroot was < 100 MBs with the app and libraries
- We created a daemon that ran in the chroot that listened for requests from the Android app via socket communications
- We then created the Android application that passed configuration and scanning requests to the daemon that dispatched the application and returned responses to Android

Simple Example #3

- Small team of 2.5 FTEs to build Android, chroot components and interface daemon
  - We had to start the chroot and the daemon from the Android init process
- Two month project including custom enclosure
- Final product:

Step-by-step for an Android Device

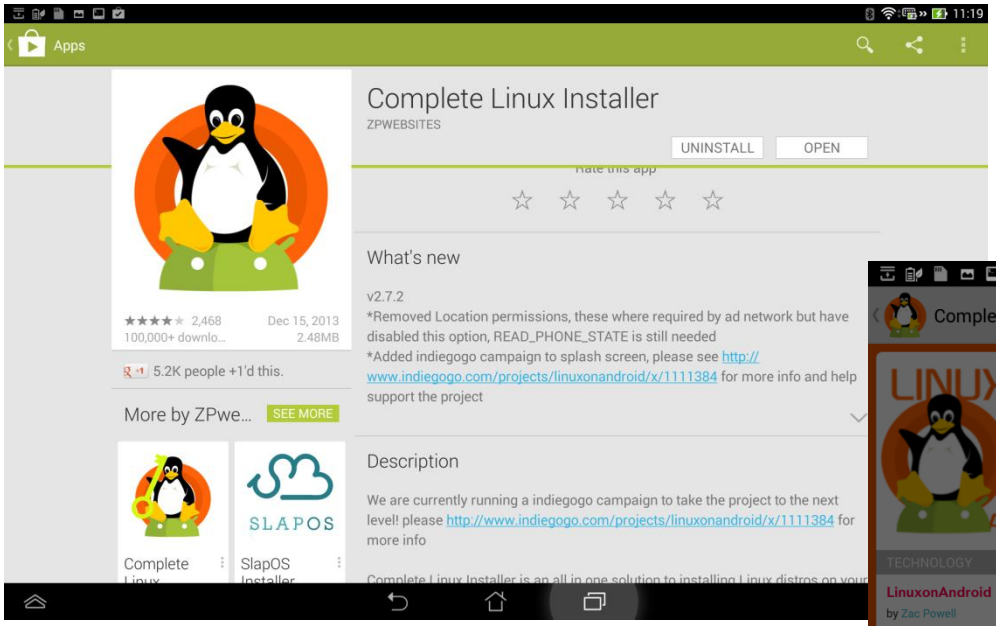
- Make sure you have the device rooted
- Go to the Google Play Store
  - Install busybox, terminal emulator and VNC client if you need Linux window manager
  - Search for “Linux Install” and you should find several apps that can install Linux
    - Pick one and install it
- Start the Linux installer, pick your distribution and download it
  - Follow the steps to install it
- Voila! Linux on your Android device
  - Linux will see your Android devices /dev and the network will just work
  - You can start an ssh server, VNC server, web server, etc. automagically

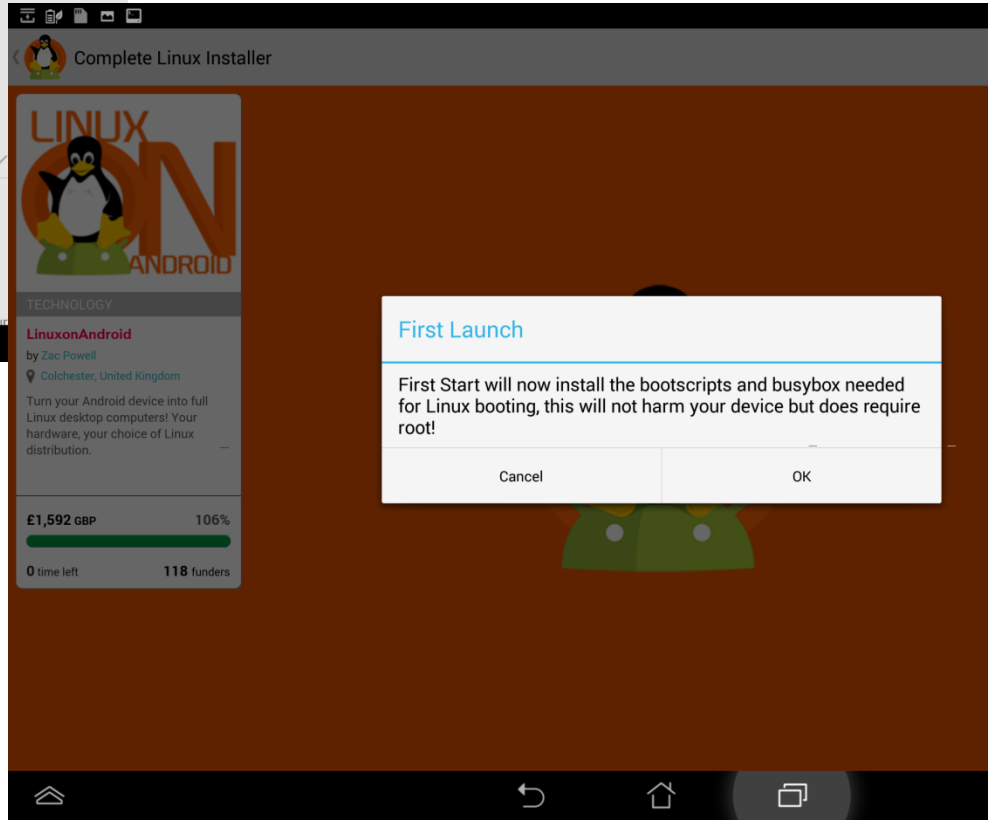
Source: google.com

Tuning the Linux Side

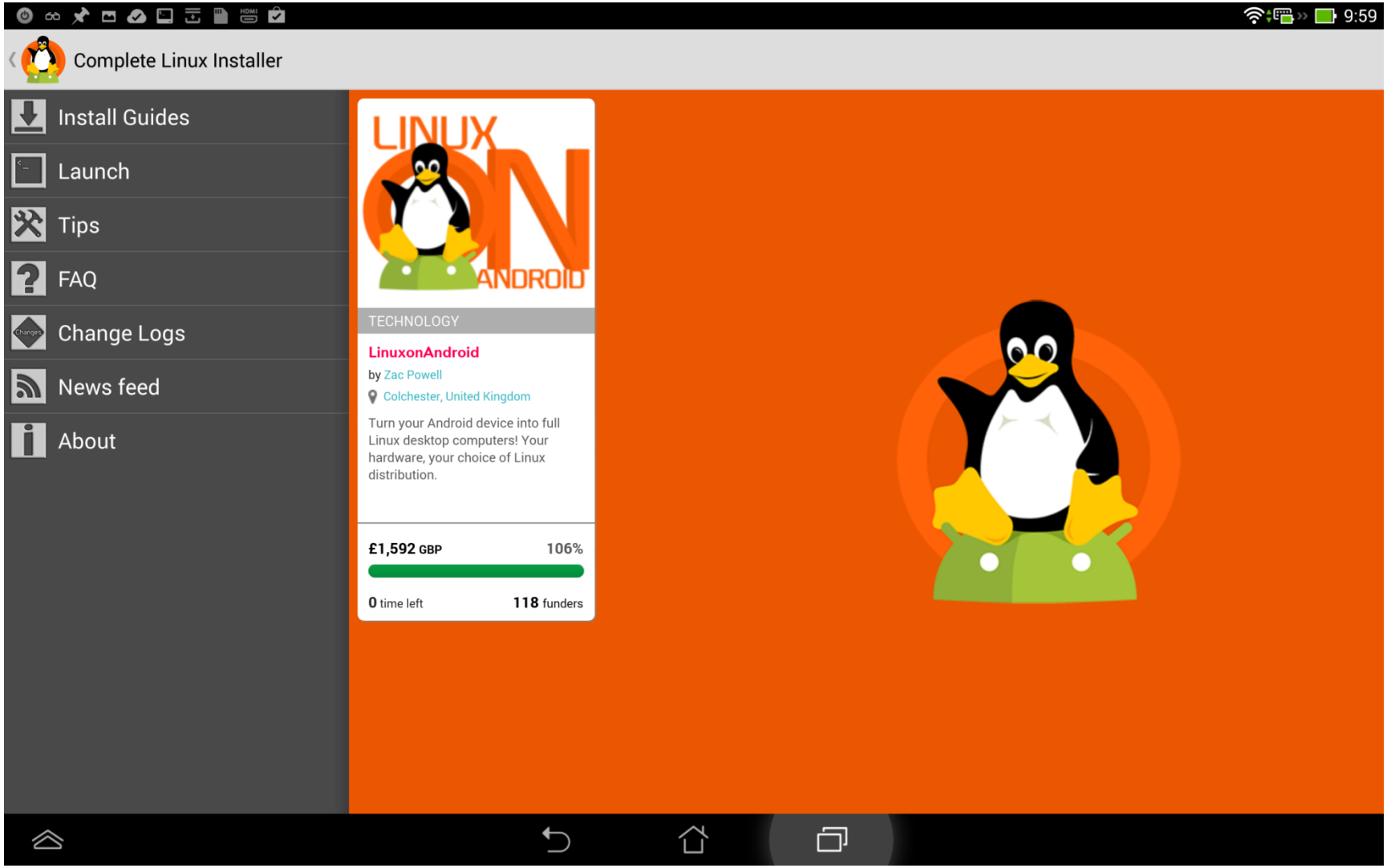
- Linux will be a console application visible in the terminal emulator
  - Graphical Linux applications will use VNC for display
- Use the Linux package manager for your variety to install additional package as needed
- You will need to edit the ~/.vnc/xstartup to add the applications you want to start on VNC connection
  - I installed lxde, but others are posible
- Set your VNC password using vncpasswd
- Start your VNC client for window manager goodness ☺

Example Walkthrough

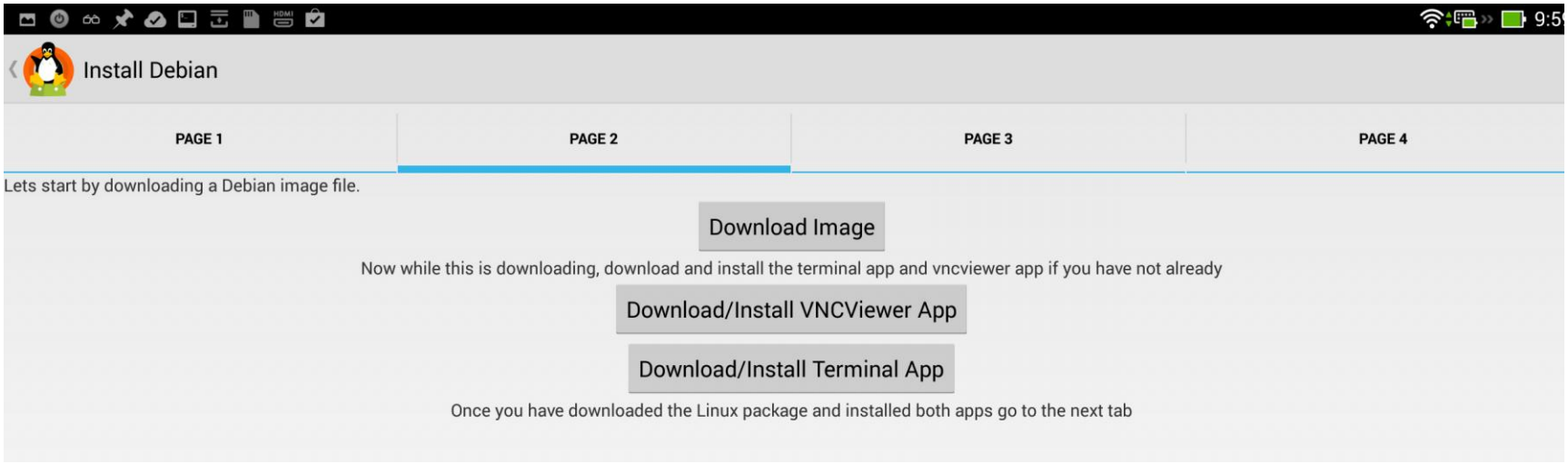


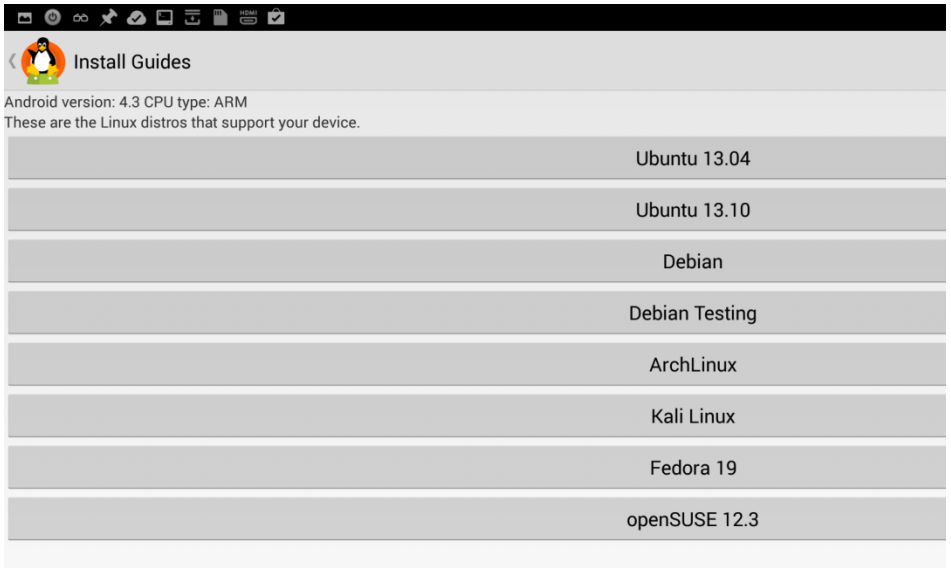


Example Walkthrough #2



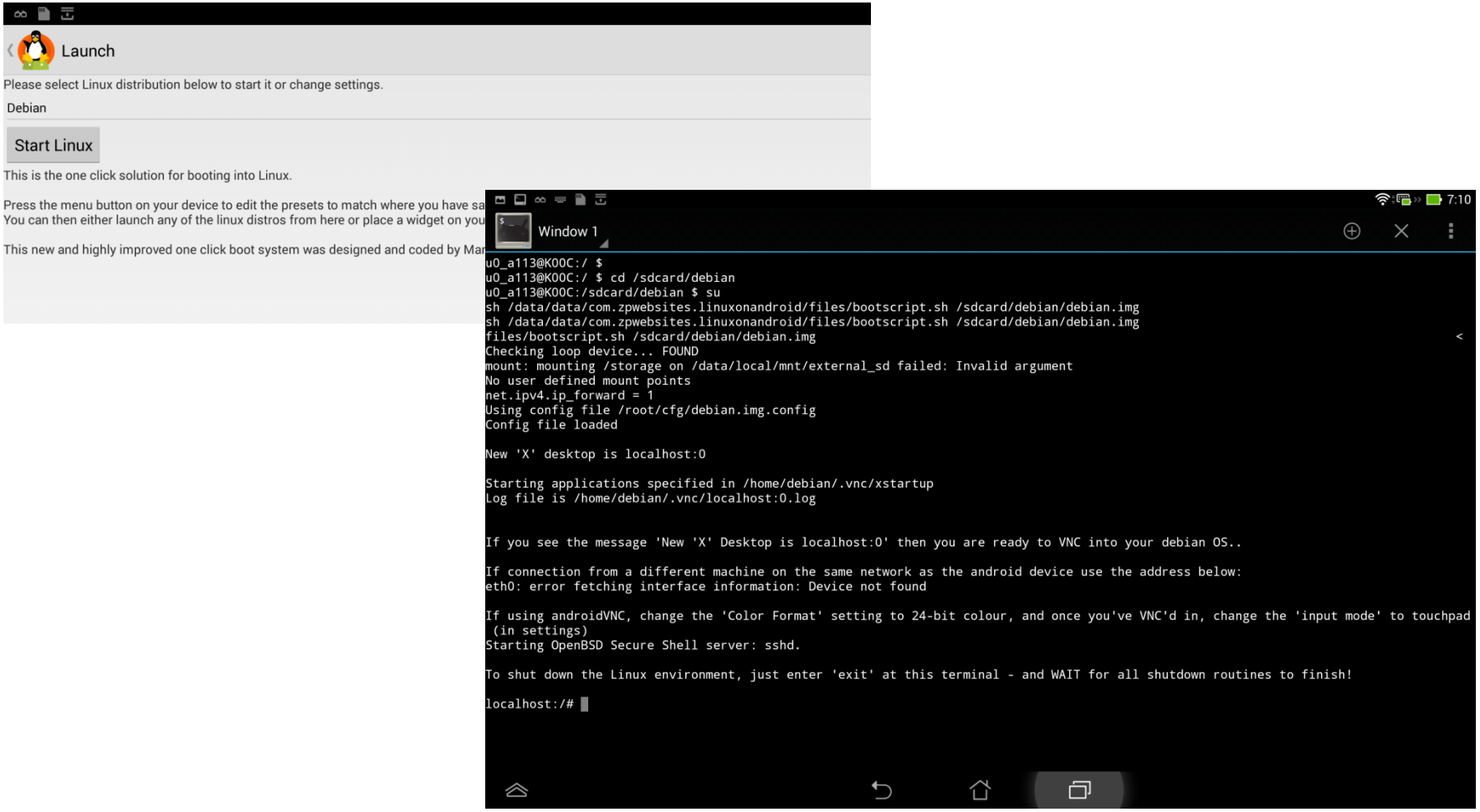
Example Walkthrough #3



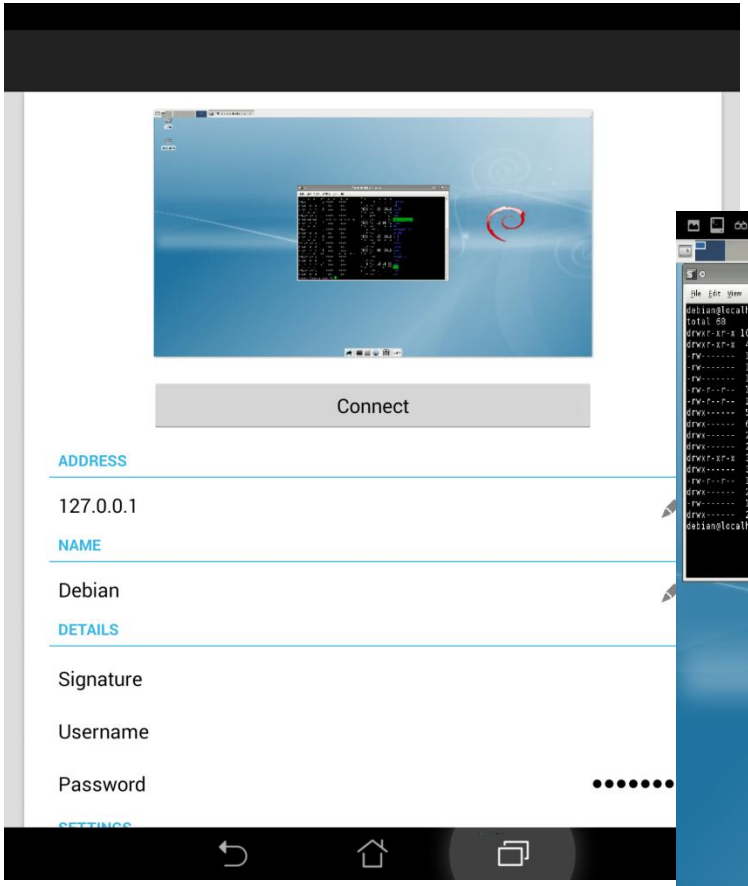


Example Walkthrough #4

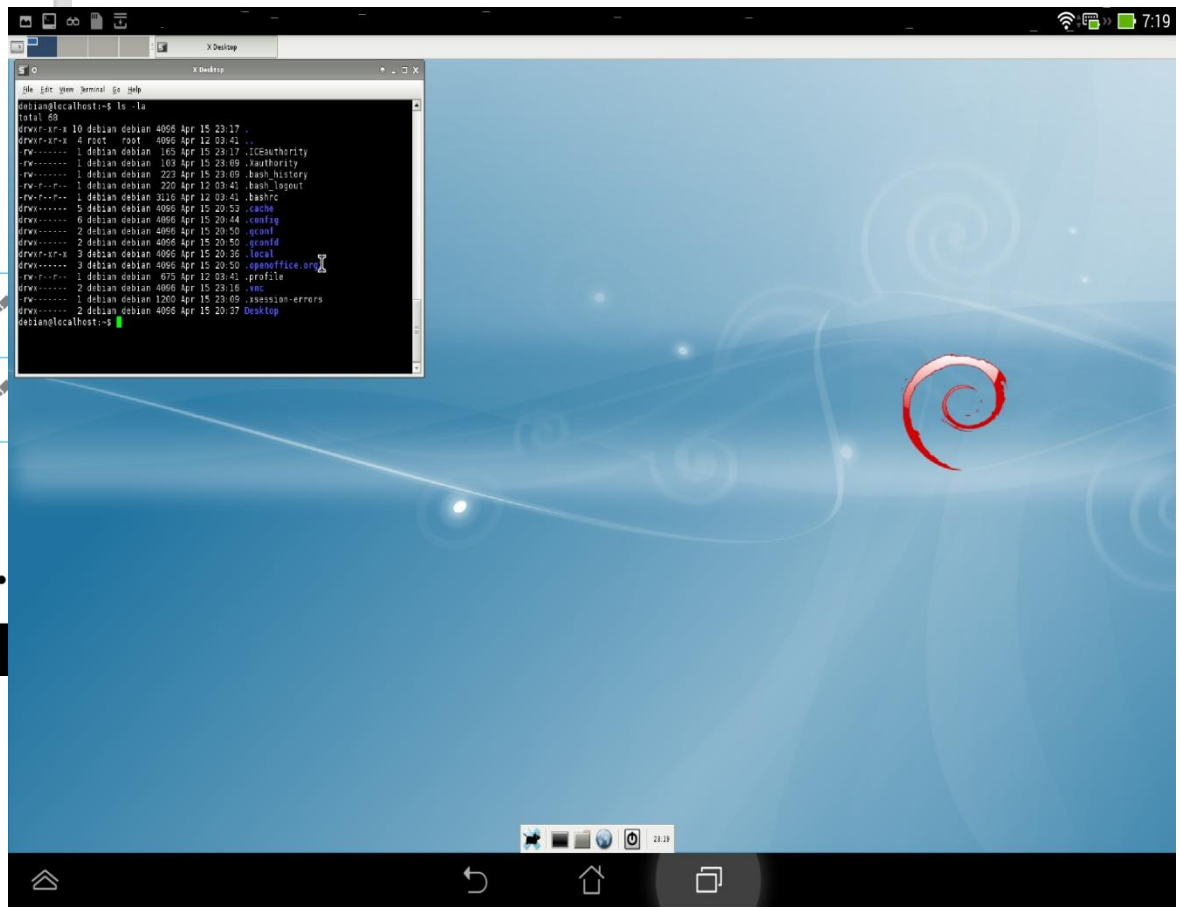
Launch Linux…



Example Walkthrough #5



Launch VNC



Communications Between Domains

- Android is missing most of the POSIX IPC mechanisms
  - No message queues, shared semaphores, etc.
- IP sockets work fine
  - Path of least resistance
- You can create your own communications channels via the kernel
  - Device drivers work via the kernel
- /proc and /sys work too

Summary

- Via the common Linux kernel, it is possible to co-host Linux and Android apps at the same time
  - Easier than porting the application to Android
  - Allows you to extend Android with existing Linux ARM repos
  - Gains access to a package management system that's more flexible than Google Play Store
  - Allows you to do native ARM development on Android
- Multi-core platforms with at least 2 GBs of RAM work reasonably well
- You can tune the chroot to contain just what you need
  - Smaller footprint
- It's fun to have everything at your finger tips in one portable platform