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sense and simplicity

Digital Television With Linux

Architecture and Opportunities

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Contents Of Presentation

- What is Digital TV?
  - TV domain and driving factors
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  - Dynamic application integration
  - Opportunities to improve system integrity

What is digital TV?

TV domain and architectural challenge

Digital TV?

- TV is far away from being just a large screen with a tuner
  - Though it still has the large screen and the tuner
- There are many similarities to other domains
  - Digital STB is a TV without a screen
  - PC can do TV watching and more
  - Phone get's more connectivity features like TV
- Consequently the TV domain is continuously changing
  - And we need to add Philips specific innovations as well
  - In an ever shorter lead time

The Digital Broadcast Domain

- STB drives a huge amount of operator diversity using variations of the standards
  - To differentiate offering
  - No strive towards standardization
  - Country specific
- Also public operators are becoming increasingly diverse
  - To differentiate offering
  - Sometimes city specific
- An increasing amount of diversity in software is required to support this
  - With subtle but fundamental differences

Standards

Applications

Devices

The Connectivity Domain

- There is an increasing amount of content available in the household
  - And an increasing amount of standards to access it
- We are used to a wide set of interactive applications to access the content
  - And hence got used to it
- Most electronic devices nowadays offer ways to access the content
  - Some work better than the other

Standards

Applications

Devices

The User Experience Domain

- Aesthetics essential part in user experience
  - Graphical experience is first view
  - A wide set of standards that provide ways to enhance the aesthetics

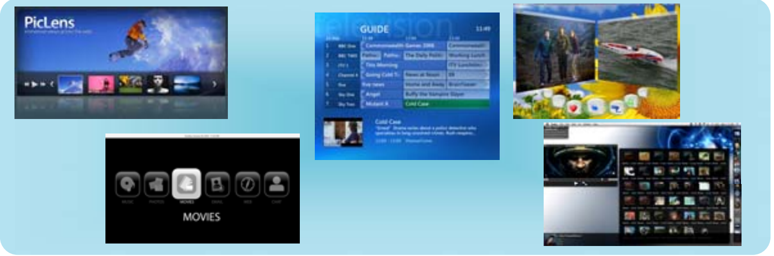
- User experience is about managing your content independent where it is located
  - Many reference applications
  - Widely used in the internet domain

- Ongoing reference set in the market
  - From the mobile, STB, and PC domain

Standards

DirectFB OpenVG OpenGL W3C WORLD WIDE WEB consortium SVG

Applications

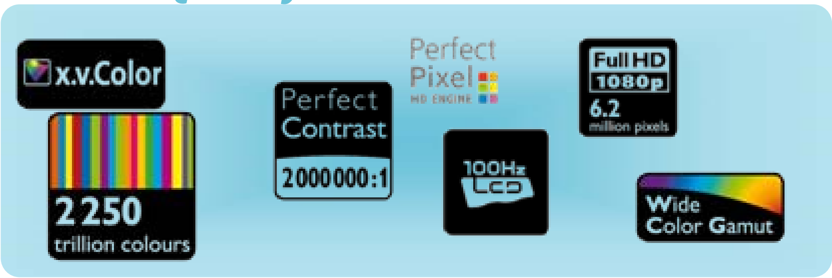


Devices

The Traditional TV Domain

- Top notch picture quality
  - Ongoing drive in the market to improve picture quality
  - Focus on all content areas (analog, digital)

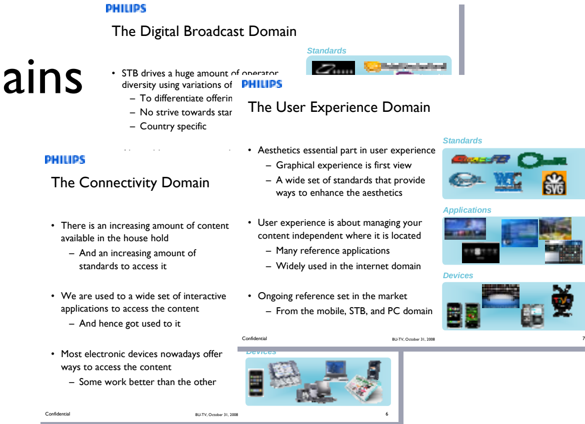
Picture Quality



AmbiLight

- Ambilight as picture quality extension
  - Improve Ambilight to be a full extensions of TV image
- This is what differentiates a TV from all other devices
  - Continues to be the big screen in the center of the house hold
  - Increasingly bring you the content you want

What Will We Explain Today?



- Standards and applications are driven from other domains
  - Wide range of existing solutions in the market
  - Both commercially and open source
  - Increasing attention for connectivity and UI
- Increasing amount of attention for CE industry in community
  - Linux offered by most silicon vendors
  - DirectFB widely picked up as standard graphics approach
  - Resource limitation is no longer a constraint, but embedded in the design
- However, making a CE product out of it is something else
  - Integrating heterogeneous SW is an increasing challenge
  - Heterogeneous being SW from different solutions and domains

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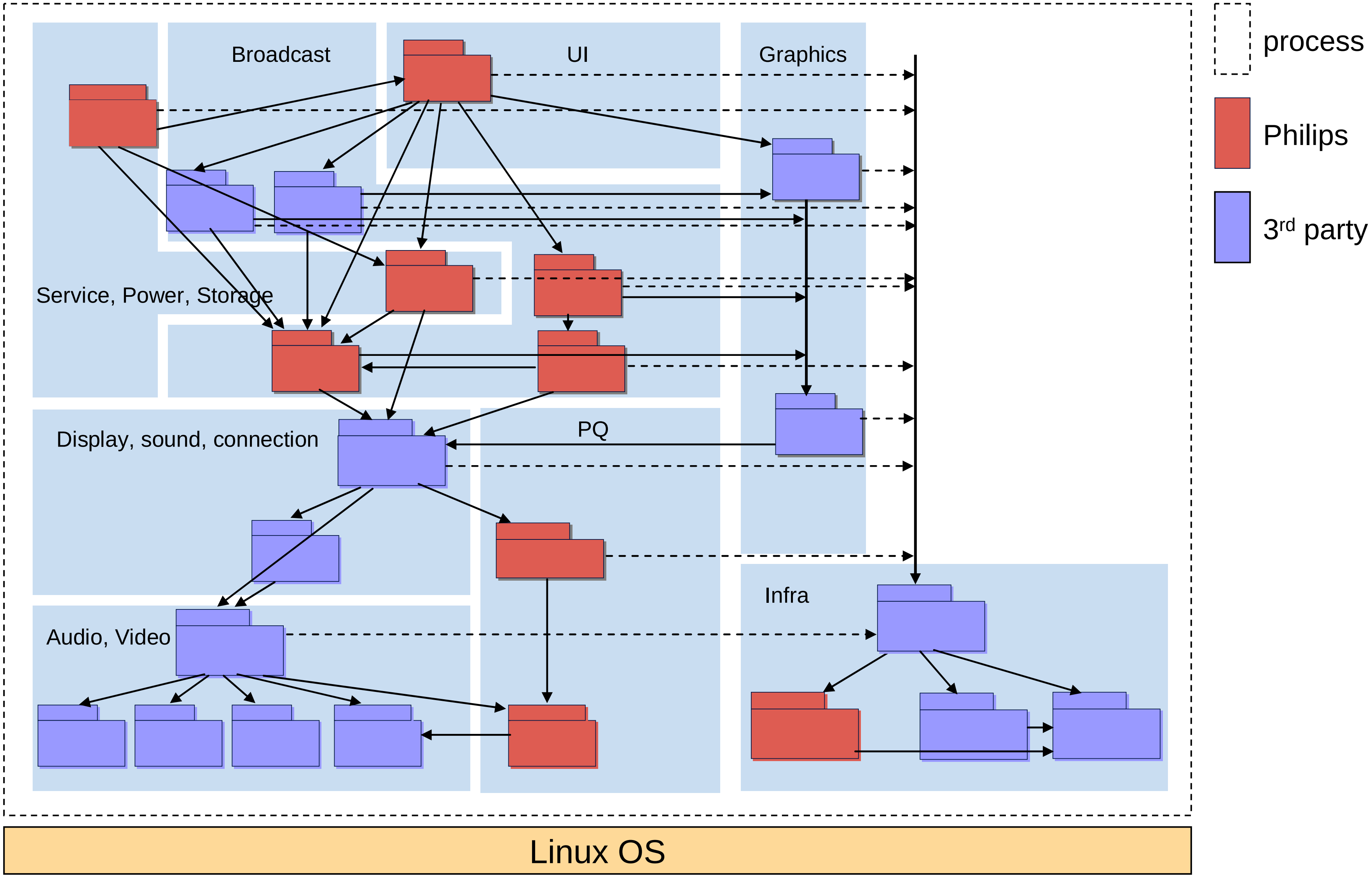
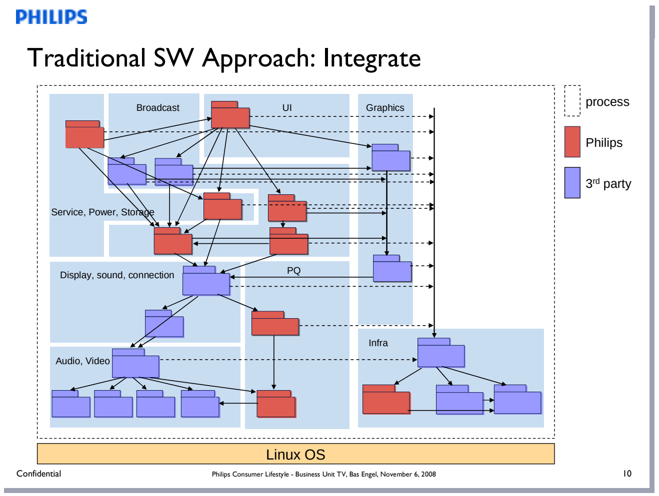
Traditional SW Approach: Integrate



Integration Nightmare

- Integration has it’s advantages
  - Optimized resource usage
  - Standard architecture approach (training, integration, etc)

- Integration pitfall
  - High effort due to increased complexity
  - Longer TTM as there is no small change
  - System validation requires global big bang approach
  - No independent lifecycle, no distributed integration cycle



What We Need: Agile Integration Architecture

- Fast and predictable integration of system extensions
  - Avoid an extensive (re)validation cycle
  - Enable convincing module test opportunities
  - Enable PC based testing
- Cater for sharing of critical system resources
  - Audio, Video, and Graphics
  - General purpose (Linux) infrastructure
- Manage building blocks fully independently
  - Limited building block correlation
  - Cater for extensions without the need to know all the details
  - Independent application lifecycle and execution behavior

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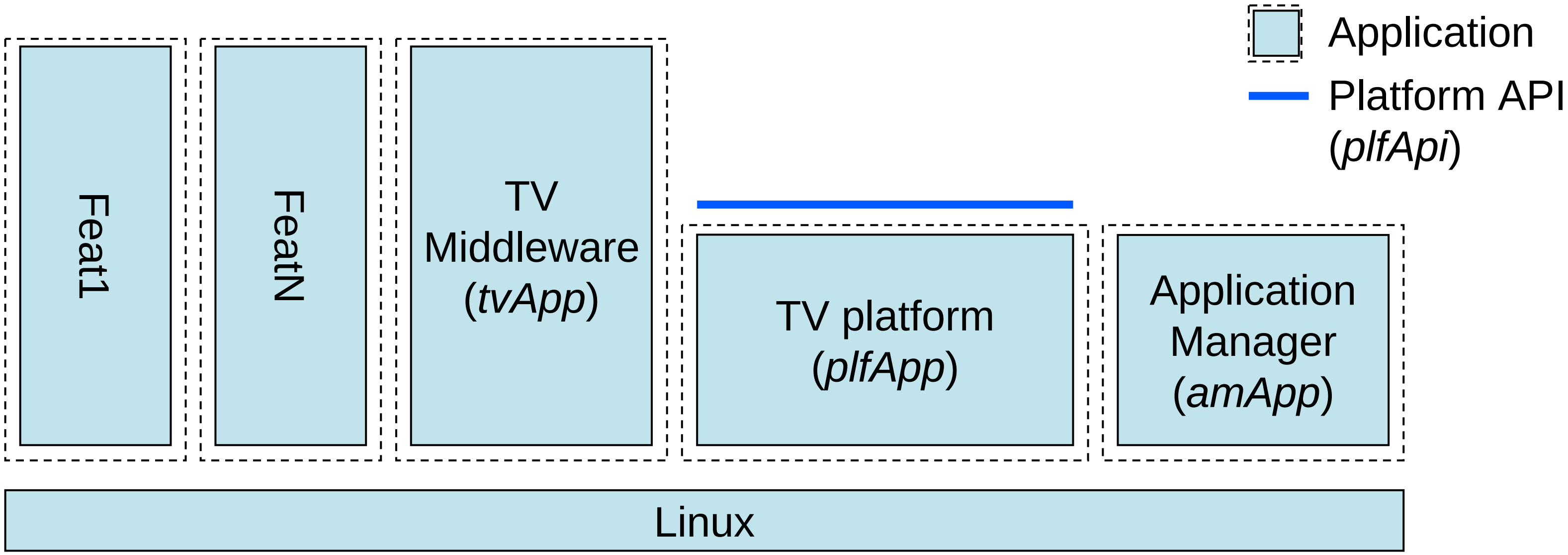
SPACE

Architecture and concept

Introducing SPACE



SPlit Application arChitecturE

- Applications are isolated in dedicated processes
- The resources in the system are explicitly and centrally managed
- The client applications are system context unaware
- The lifecycle, focus and visual layout of the client applications is centrally managed

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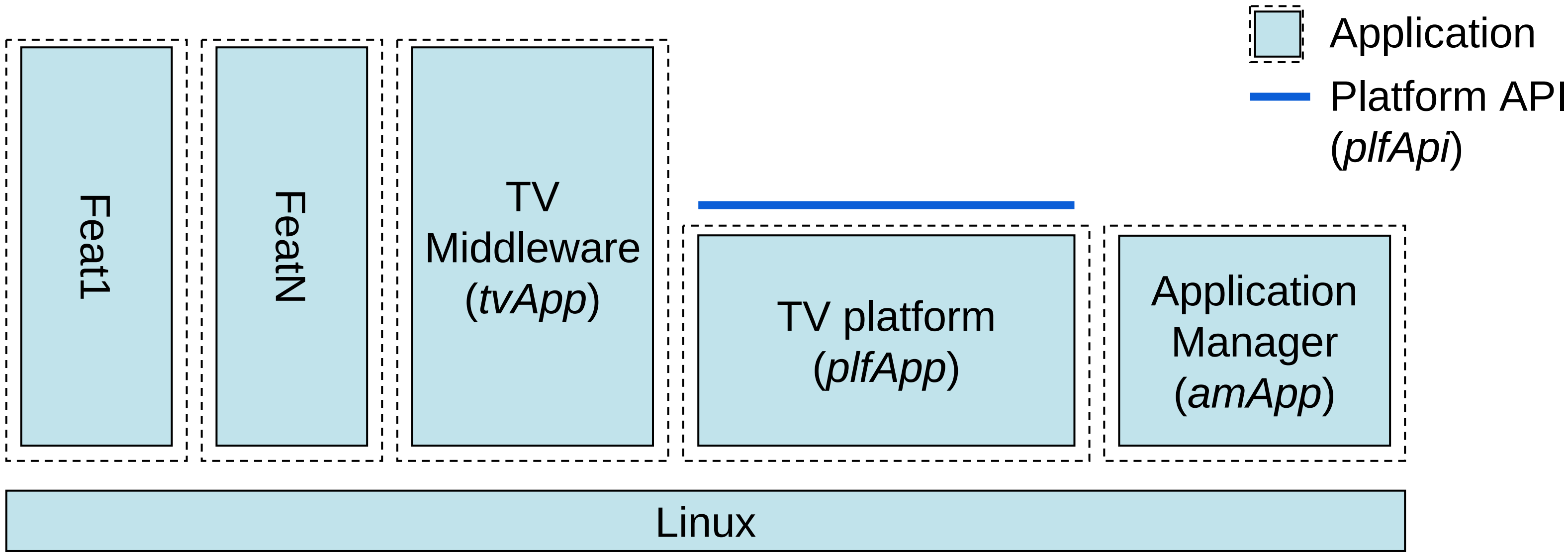
Key Architecture Rule



pAPI only allowed IPC

- Synchronous function call allowed only towards plfAp
  - Gated via resource model
- Notifications/events are allowed between applications
  - Without any synchronization allowed

Applications orthogonality
Dynamic behavior cannot be dependent on other applications

Essential Building Blocks

- Application Manager (amApp)
  - Control center of the system
  - Manages application lifecycle, focus, and layout
- Television Application (tvApp)
  - Core TV functionality
  - Broadcast, installation, and general TV settings
- Platform Application (plfApp)
  - HW platform abstraction layer
  - Audio Video and Graphics control
- Platform API (plfApi)
  - Philips AVG control interface
  - Philips Audio-Video API to control platform by applications

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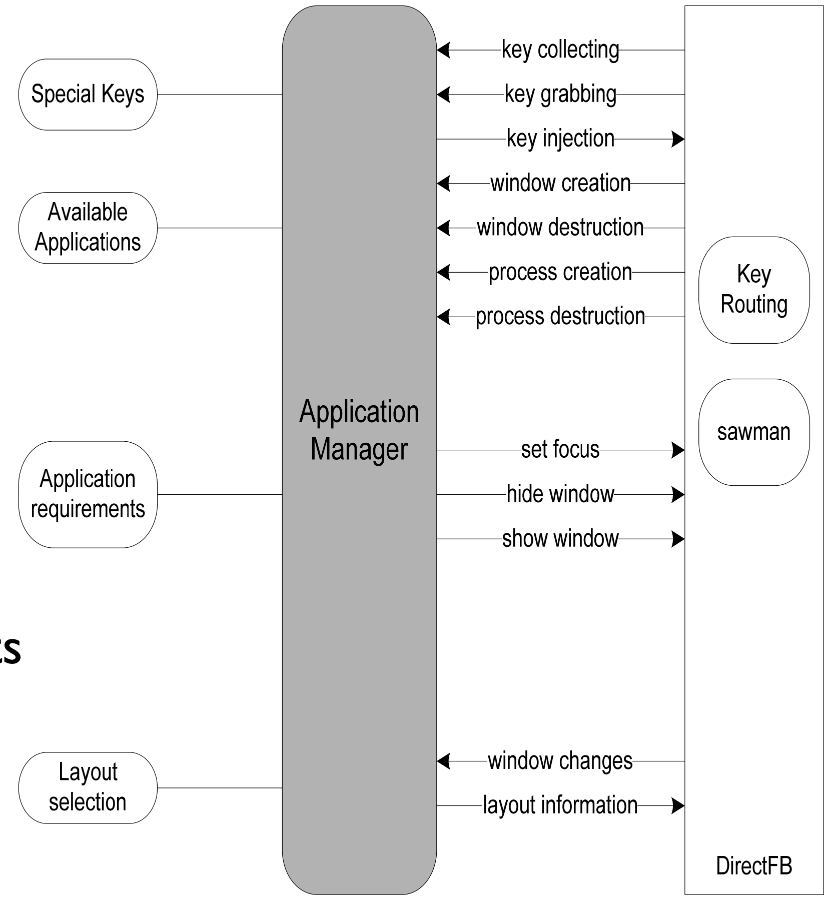
Application Manager

- Application lifecycle management
  - Starting, stopping applications based on remote control keys
  - Knows the system requirements of all applications
- Focus handling
  - Determines the active window, reacts to user request
  - Manages the application requirements to the AV resources
- Layout management
  - Determines how the applications are presented



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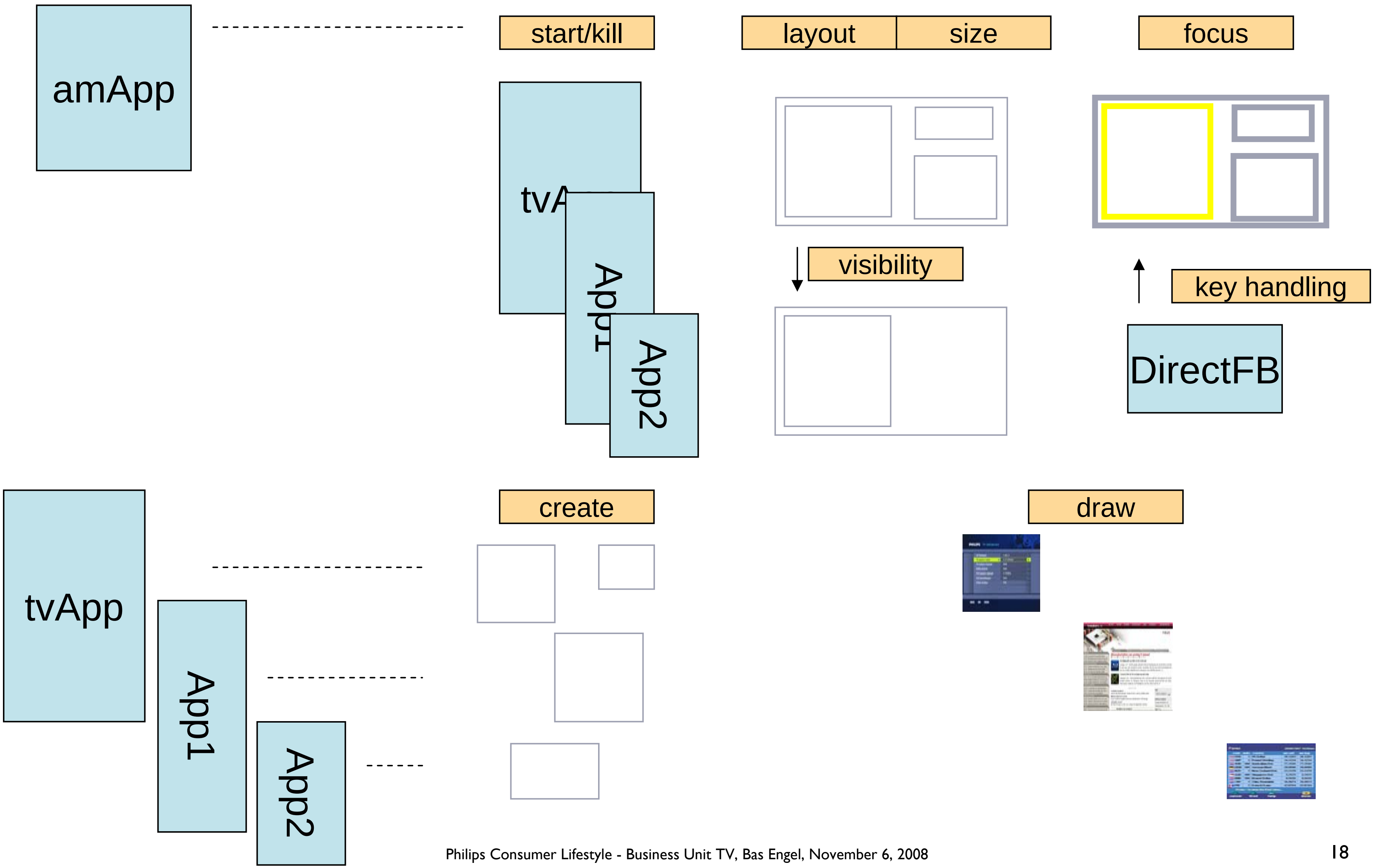
Responsibilities



Managing resources

- There are implicitly managed resources by the kernel
  - TCP, flash, USB
  - Memory allocation
- There are explicitly managed resources
  - AV platform resources
  - Memory and CPU resources
- The explicitly managed resources
  - Have a statically defined execution behavior
  - Can by design limit the parallelism in the system
  - Require an explicitly resource controlled system

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Dynamic Resource Management

- amApp has a fixed list of possible resource per application
  - Worst case requirements for an application (as per today)

- Application requests the resources it needs
  - Via an explicit list

- amApp assures resources if application is in focus
  - Only the resources that are allowed (fixed list of possible resources)
  - Can mean other applications loose resources (without stopping them)

- An application never releases resources
  - Always taken away by amApp

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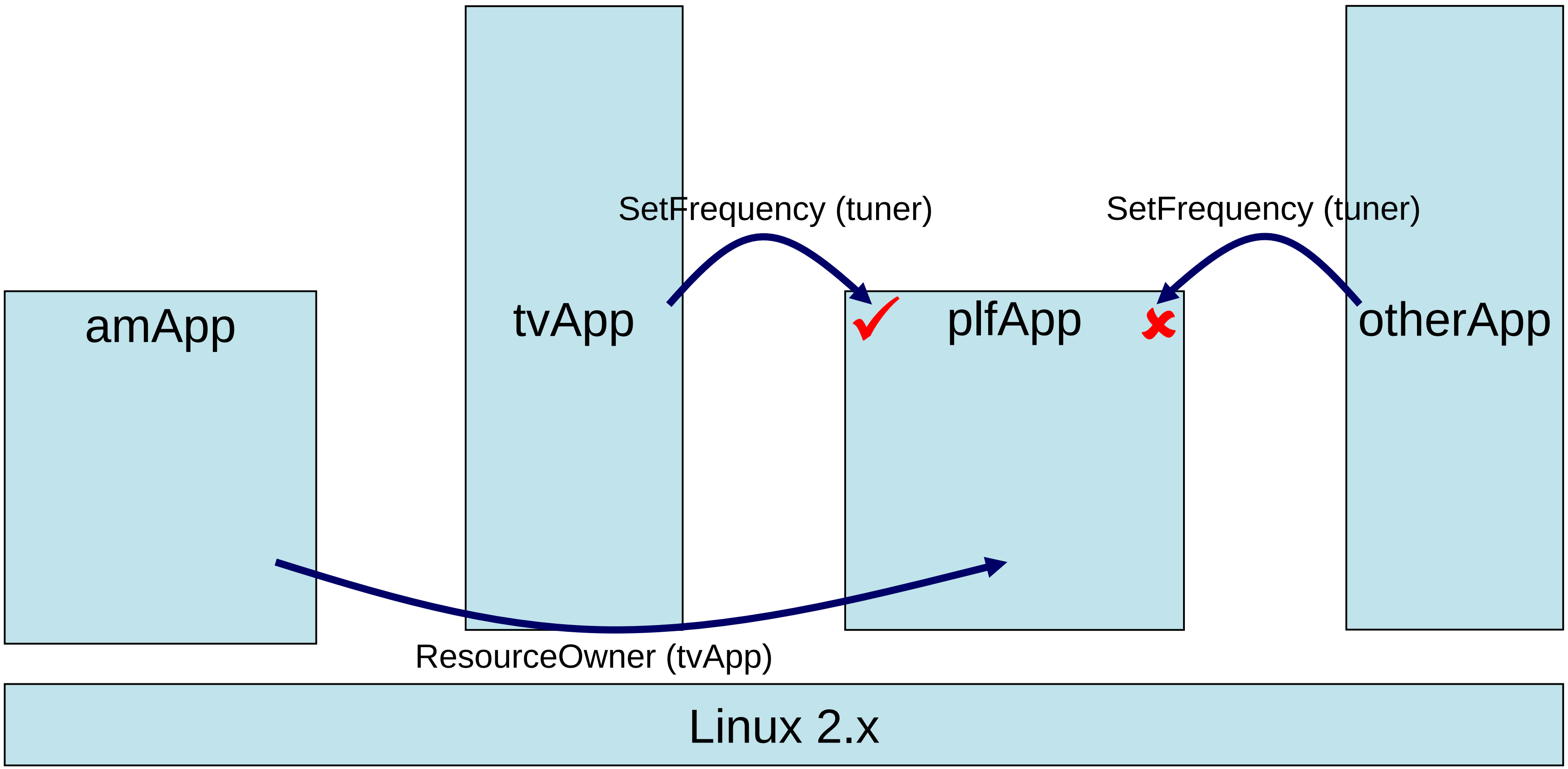
Multi Client Management



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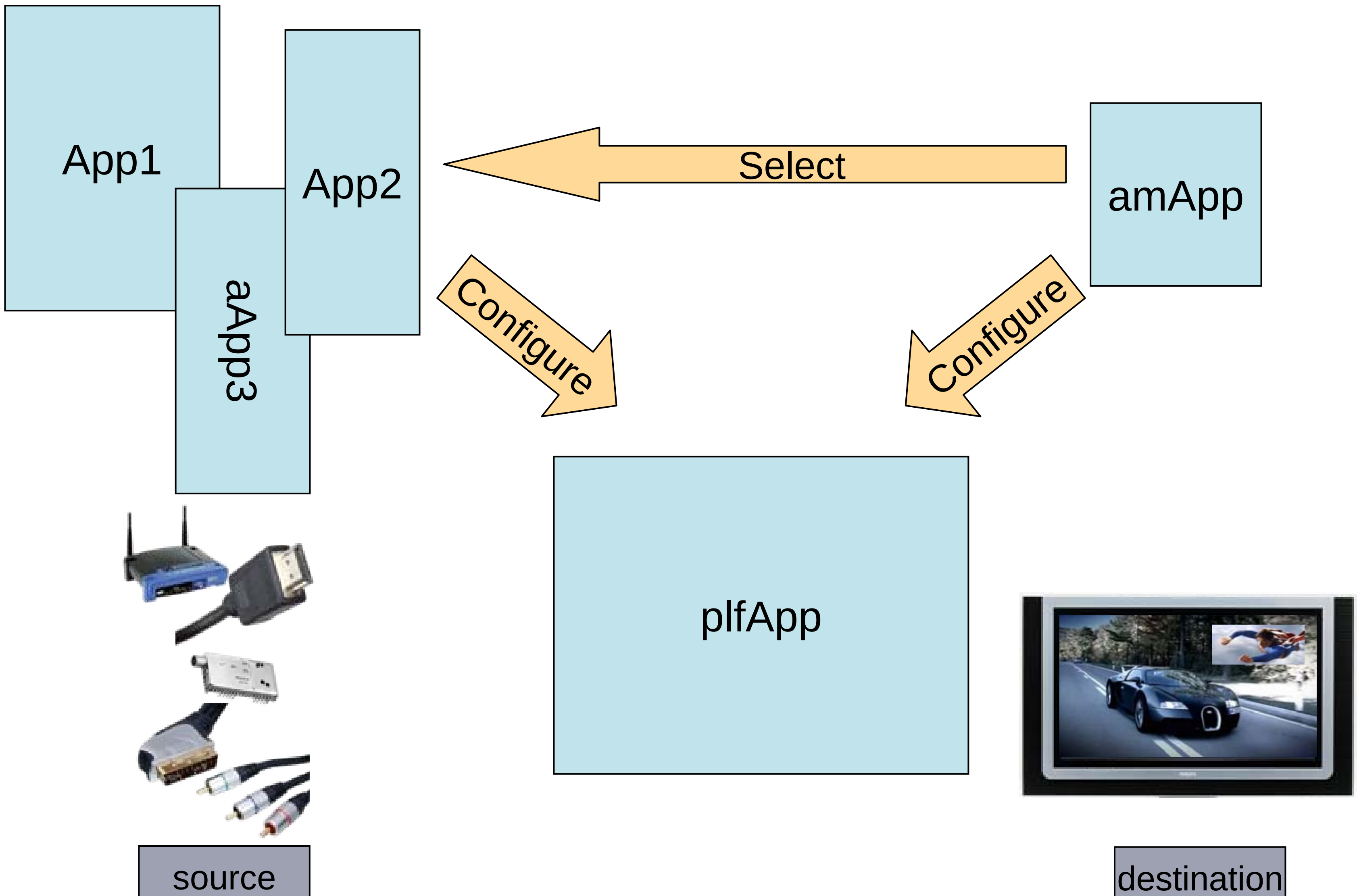
General Connection Management Concept

- Connection Management is split up in
  - Destination setup (full screen, window)
  - Source setup (HDMI, tuner, DLNA)
- Connection Management is distributed
  - Application Manager is responsible for destination setup
    - Application Manager is source unaware
  - Client applications are responsible for source setup
    - Client applications are destination unaware
- Identical approach for all use-cases
  - Audio, Video, and Graphics sources

Audio/Video Connection management



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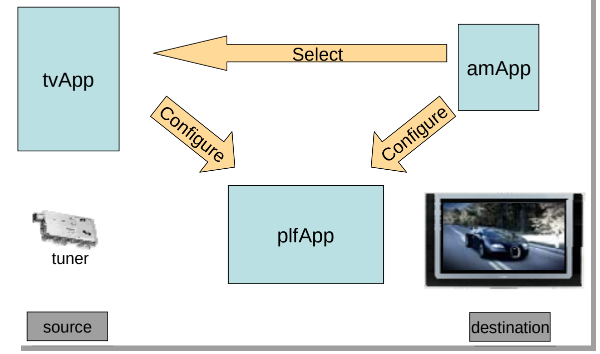
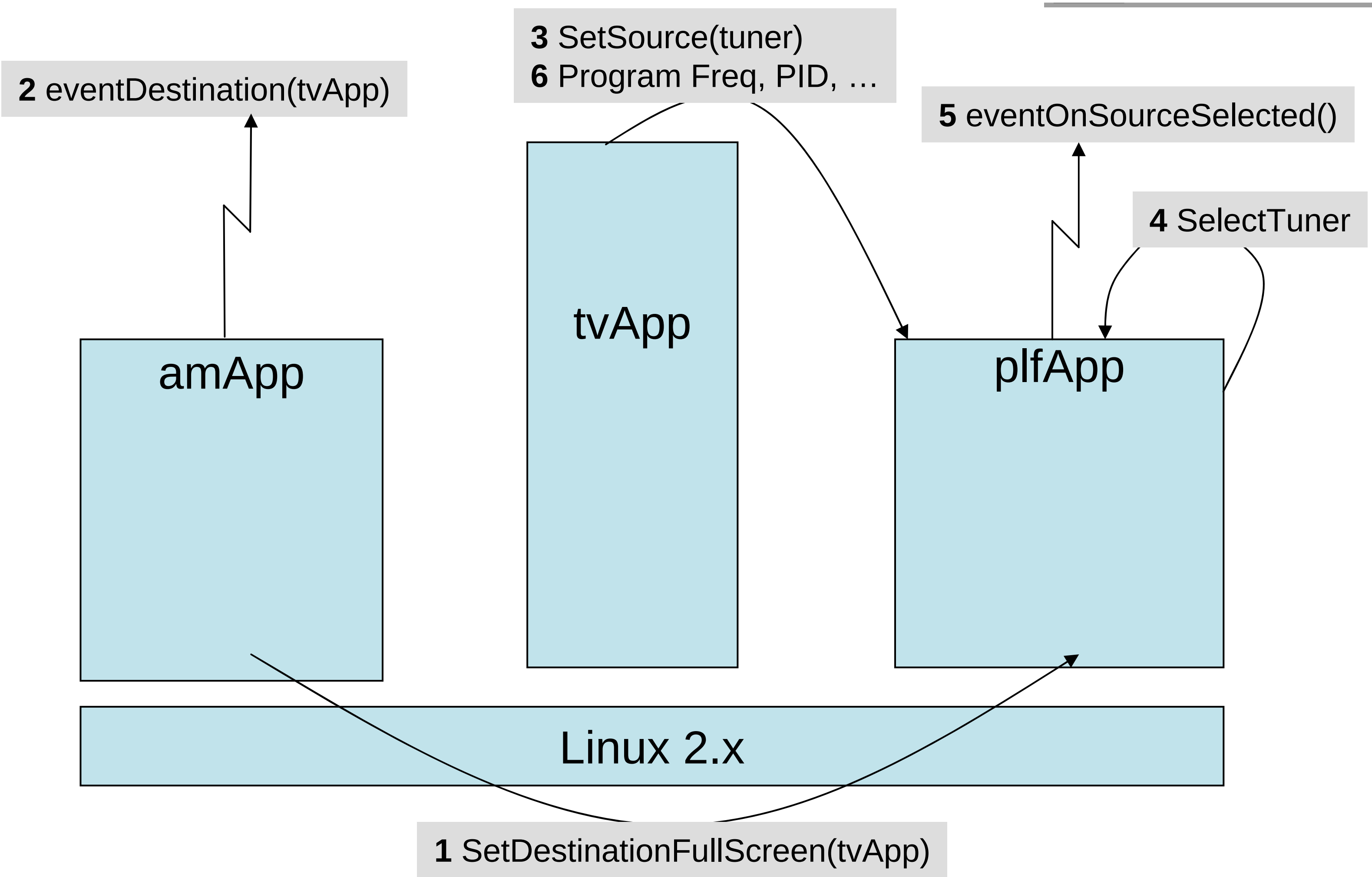
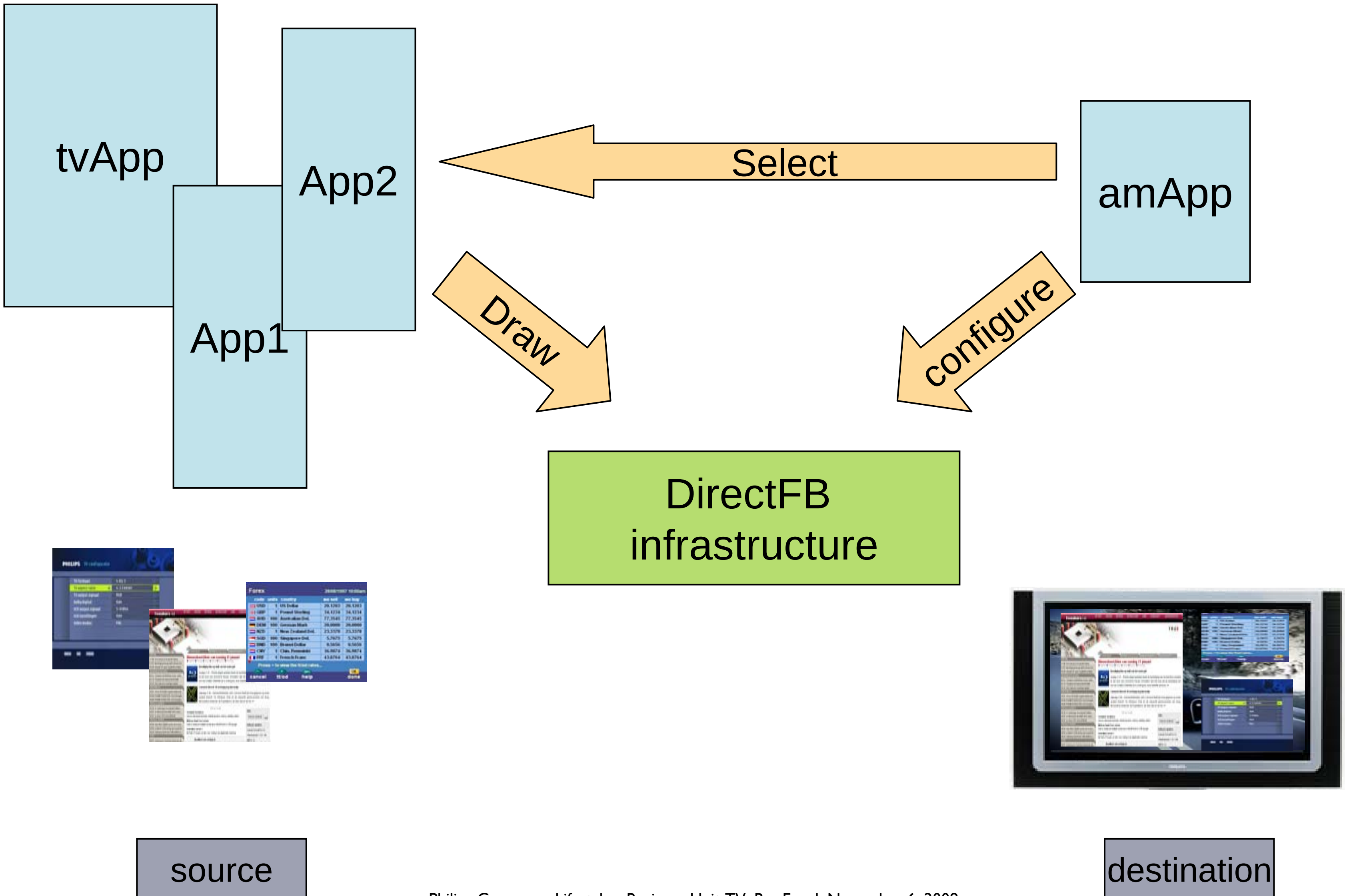
Example

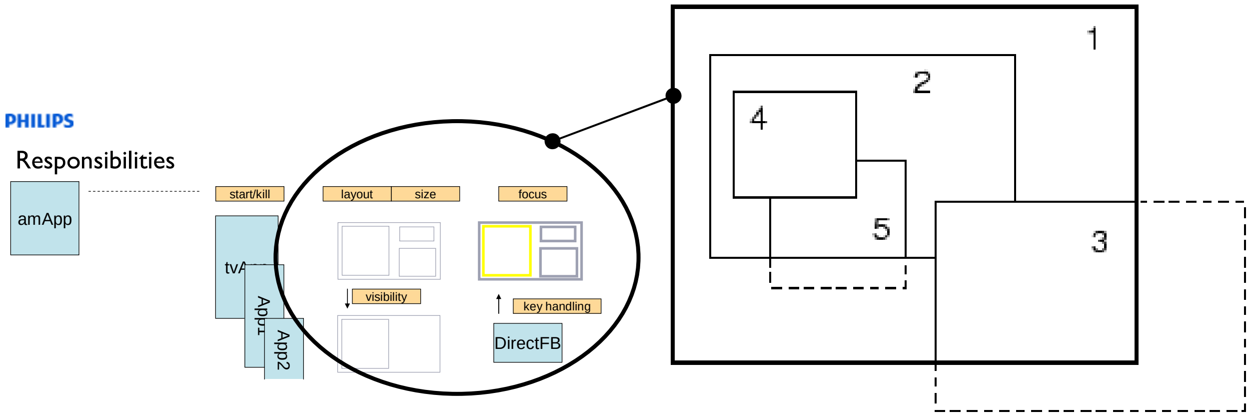




Graphics Connection Management



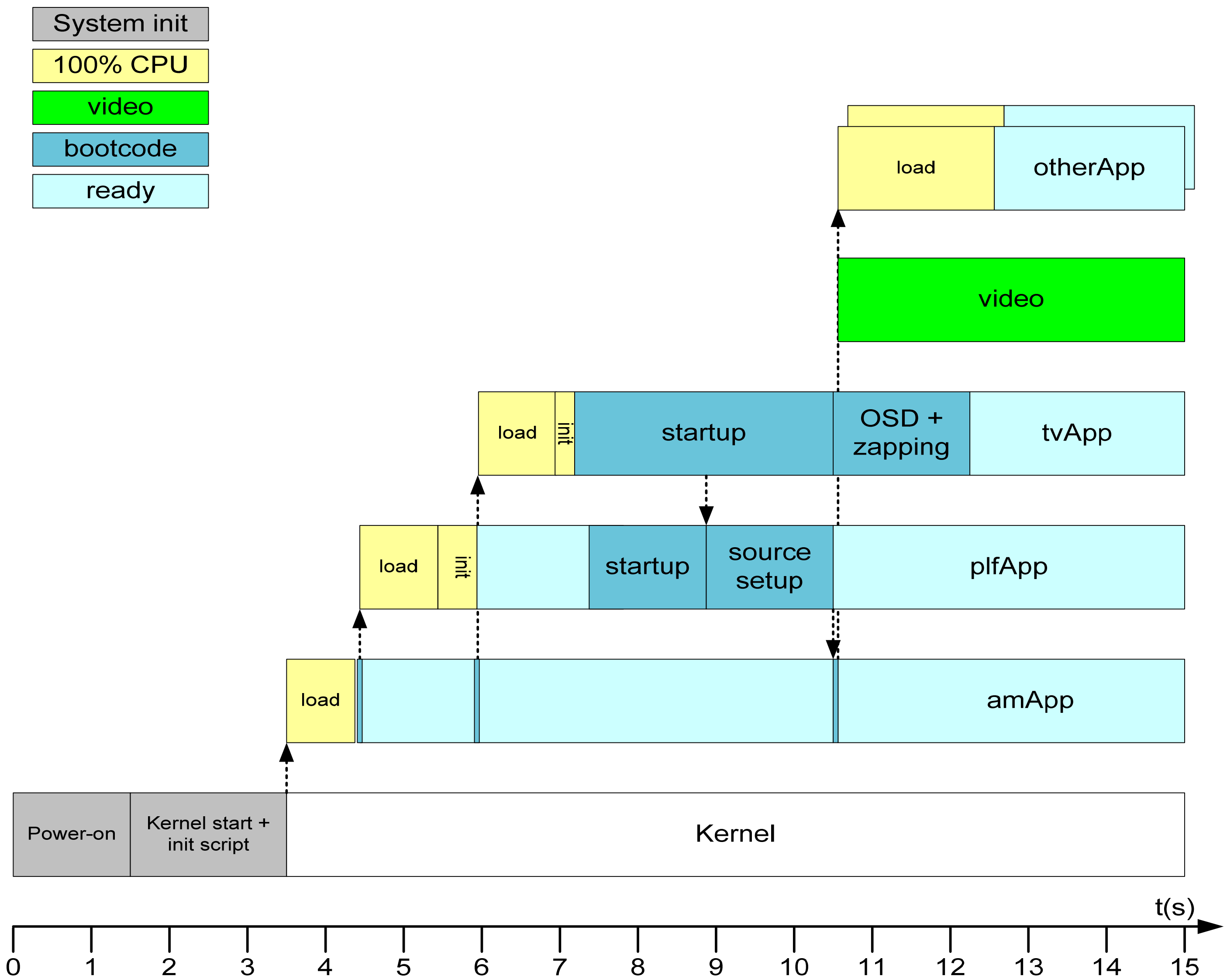
Window Management



1. whole screen
2. top level window
3. top level window
4. subwindow of 2.
5. subwindow of 2.

- Application manager responsible for all top-level windows
  - Z-order, focus, association, pixel format, layout
- Application are able to do their own internal window management
  - Applications use multiple windows for OSD like scenarios
  - Always slave of top-level window managed by application manager
- Application can create 1 or more sub-windows within 1 top-level window
  - A sub-window is linked to a top-level window

SPACE Boot Architecture



Key Optimizations Areas

- Use pre-linking for all SPACE applications
  - All SPACE applications are pre-linked (30% load time gain per application)
- File system optimizations
  - Optimize ECC and block loading
  - Separation of data and code partitions, reduce mount time
- Only initialize what is needed
  - Delayed mounting where possible of JFFS2, USB, Ethernet, etc
  - Use paging for all applications
- Parallelize tvApp and plfApp
  - Make sure during initialization the system runs at 100% CPU

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Secure Boot

- Security/Robustness rules imply application integrity
  - Only start applications that have been verified to run on the system

- Use hash based algorithm (sha1) to verify application
  - Required for all executable code that could tamper with the system
  - Restricted to code that could access security data (key, license)

- We identified 2 options
  - Preferred solution: Accelerated RAM disk
    - Pre-load all applications, use HW to accelerate RAM disk verification
    - Verification and loading block based and fully parallel, no boot time increase
    - BUT, loading applications from RAM disk (instead of squashfs) to RAM: +2s
  - Traditional SPACE startup
    - Verification and loading block based, all done by Linux OS: +1s

Critical Success Factors For SPACE

- Avoid system requirements that require interweaved applications, like
  - Integrated zaplist for bolt-on and native zapping
  - Synchronized transition handling across applications
- Accept consistent behavior
  - We have to accept that not everything is possible in SW
  - No more exceptions to realize that one ‘important’ requirement
- Do not accept any synchronous communication between applications
  - A-synchronous events rigorously managed by architecture team
- Streamline organization towards SPACE
  - Specifically addressing reuse, responsibilities, release mechanism, diversity

The Transition Towards SPACE

- Major change in execution architecture
  - From single process (7 threads) to multi-process (unlimited threads)
  - From real time user space scheduling towards pre-emptive one
- Release an efficient multi-process resource management
  - Avoid explosion of memory requirements
  - From single client AV resources towards multi client
- Move from single application towards multiple small ones
  - Understanding where and how to split
  - From centralized control architecture towards distributed one
- Infrastructure change
  - From proprietary solution towards DirectFB
  - Enhancing DirectFB towards an embedded windowing system

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Does SPACE Deliver It's Promise?

- Shorter lead time of new features
  - Orthogonality in functionality is essential part in TTM
    - Significantly reduced validation time of extension to basic system
  - Diversity simplification
    - Much easier to create differences between products

- Reduction of complexity
  - System is composed of logical self-contained building blocks
  - Less dependencies and far better to manage architecturally and project
  - No need to understand full system details for new features

- Improved portability
  - New HW platform impact restricted to plfApp
  - Execution architecture impact better contained locally

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Next Steps

Dynamic application integration, system integrity

SPACE Rapid Prototyping Environment

- SPACE on PC enables fast prototyping of future TV use-cases
  - Enhanced multi-window
    - Compose multiple input streams
    - Real window rendering on PC
  - Vector Graphics and 3D graphics
    - OpenVG, OpenGL, SVG and Flash, DirectFB Water
  - All via PC cards and prototype extensions

- Fast turn-around of innovations
  - Space on PC is Space on target
    - Exception is performance
    - Graphics, key handling, plfApi are all identical
    - Communication, watchdogs, events are all emulated
  - Allows to develop and mature TV applications on PC

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SPACE Run-time Configuration

- SPACE is designed such that applications run orthogonally
  - Applications do not influence each others dynamic behavior
- Via the existing infrastructure an application can easily be added
  - Application Manager does not restrict where applications are located
  - Dynamic resource manager enables plfAPI to be used by any one
  - DirectFB has a multi-window and multi-control concept
- There are some challenges still
  - Applications must be restricted in what they can access (sandboxing)
  - Applications must be validated before they can run

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Ongoing Investigation

- Execute applications in a controlled environment
  - To restrict impact of application on system to ensure system stability
  - To prevent access to secure information (keys, DRM)
- Containment on various aspects
  - Limit files accessible
  - Control access to certain API's (plfApi, DirectFB, network, …)
  - Constrain CPU usage and memory bandwidth usage
- We are investigating how to support sandboxing
  - Existing solutions seem to be an overkill for TV (eg virtualization, selinux)
  - Other solutions are not addressing the full scope (eg chroot)
  - Other initiatives are unclear if they bring an integral solution (eg cgroups)

Conclusion

Conclusion

- We described the need for a next generation software integration model
  - Addressing the emerging standards and services driven from STB domain
  - Enabling the ever growing content to be managed and accessed
  - Realizing the simplicity promise and easy control of functions
- SPACE addresses the integration challenge
  - Enabling orthogonal software integration
  - Realizing a simplistic resource model that is truly multi-client
  - Leveraging the power of a standard Linux infrastructure
- SPACE could be taken to the next level
  - Must understand how to get around security and stability restrictions

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