An Object Oriented Operating System

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Introduction

- ✧ We're taking a closer look at *HAIKU*
- ✧ A free and open source operating system
- ✧ Object Oriented design
- ✧ Implemented in C++
- ✧ We'll look at selected classes
- ✧ *… and how they are used*

History

- Inspired by BeOS
  - A closed source, object oriented OS developed by Be Inc.
  - Started in the early 90's. Targeted at desktop users specifically
- Envisioned as a multimedia platform
  - To compete with OS-X and Windows
  - Failed to capture market share
  - But did enjoy a small, loyal following
- Be Inc. acquired by competitor Palm Inc.

  (BeOS development ceased as a result of it. Last release was R5, named "Dano" in 2001)

History (2)

- Haiku started in 2001
- Main Goal: Pick up where BeOS left off
- Not a clone project *(But a full reimplementation)*
- Implemented largely in C++
  - Parts of the kernel written in C with C++ wrappers
- Open Sourced under MIT license
- Still an active project today …

Overview

- ✧ Divided into subsystems (called “Kits”)
- ✧ Provides source code & binary backward compatibility with BeOS
  - ✧ Apps written for BeOS can run on HAIKU
  - ✧ A clever design choice: *Haiku comes into being with a wide range of apps ready*
- ✧ Modular design of BeOS
  - ✧ Allowed “Kits” to be developed in relative isolation
  - ✧ Written as replacements to the BeOS subsystem prior to the barebones Haiku being up and running

Overview (2)

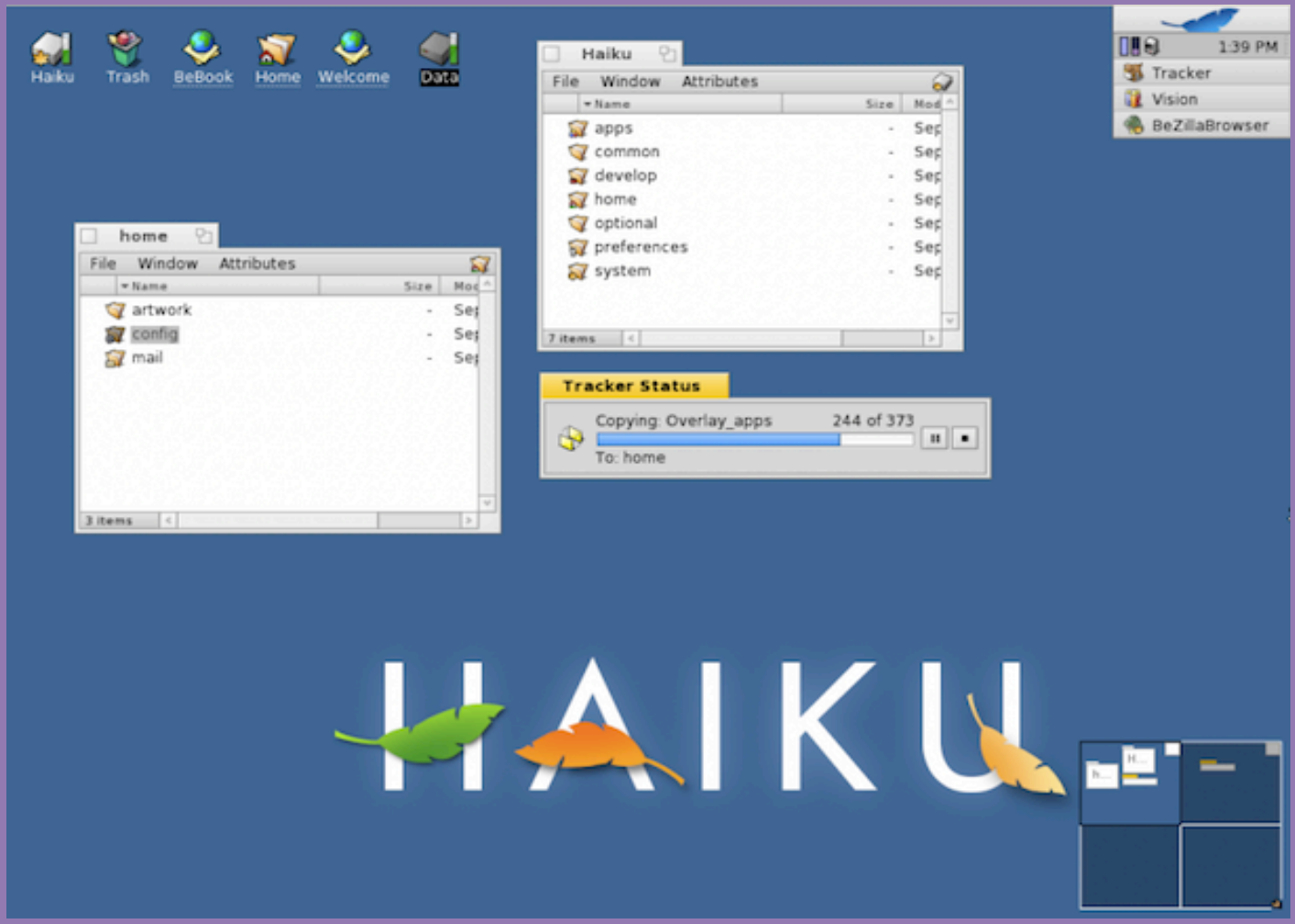
- Optimized for desktop responsiveness
- Hybrid Kernel design
  - Somewhat in between a monolithic & microkernel
- Kits: Cleanly divided Modular Subsystems
  - Application
  - Device
  - Kernel
  - Networking
  - Media
  - Printing
  - … many others

Some Methodologies seen

- One way to tackle each problem
  - Easier to test and debug
  - i.e One Desktop, One GUI
    - *Contrast with Linux, where there are different desktops bundles available, each with its own unique set of bugs.*
- Rich APIs built into the OS (rather than as libraries)
  - Avoids excessive lib dependencies
    - *Libraries are still supported, so its not all built-in*
- Both of the above promote code reuse
- Modular and extensible design
  - Examples we'll see: Replicants, System wide Messaging service

What does it look like?...

Similar to a GNU Desktop System



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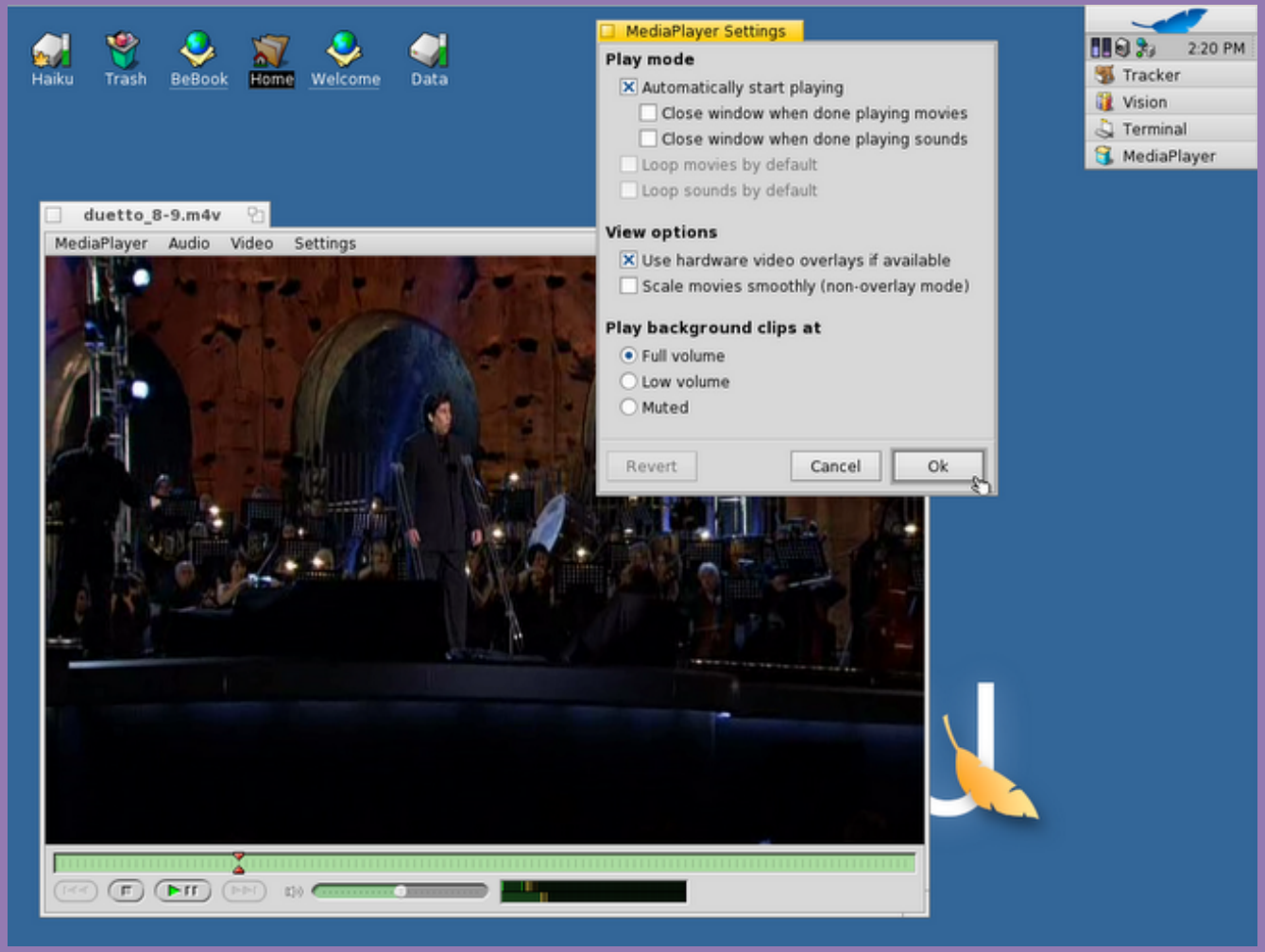


The Application Kit

- ✧ Starting point for all applications
- ✧ Collection of classes that an application uses to make itself an identifiable entity
  - ✧ Implies it can communicate and interact with the rest of the apps and the system
- ✧ All except the very simplest of apps will make use of classes contained in this kit
- ✧ Classes related to messaging *(like IPC)* , scripting support & application monitoring

The Application Kit

A closer look at its classes

- BApplication
  - Connects to the App Server (daemon), runs the applications main message loop
- Messaging Kit
  - Provides classes that implement the messaging service threads can use to talk to each other
  - Service used for both, *inter* and *intra* process thread communication
  - Also used by System to send messages to applications
- Scripting Kit
  - This helps provide scripting support to any application
  - i.e Allows the application written to be controlled by commands issued by other applications

The Application Kit

A closer look at its classes…

- BRoster
  - Provides Application/Task monitoring services
  - Can help identify applications, launch them, setup communications with them
- BClipboard
  - Provides an interface to clipboard (where “cut” and “paste” items are stored)
- BCursor
  - Represents a cursor in an application
  - Other classes lets you assign cursors to all or part of your application

The Application Kit

Messaging Kit Classes

- BLooper
  - Receives/sends and processes messages between applications
  - Does this in a separate thread
  - Passes received message to a BHandler
- BHandler
  - Handles messages passed on by an apps BLooper
  - BLooper is actually a subclass of Handler
  - Can also be used as a state machine to keep track of state of the application
- BMessage
  - A message container/unit of communication
  - Sent between process/threads using the messaging system

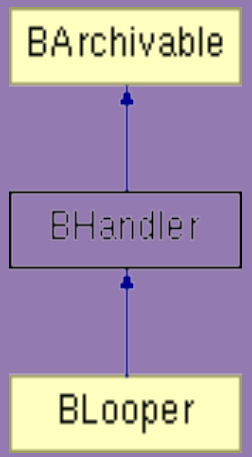
The Application Kit

Messaging Kit Classes…

- BMessageFilter
  - Can describe BMessage properties that an incoming message should have to be processed by the BLooper/BHandler
  - Is also extensible by using its *filter_hook* method
  - Filtering based on 2 other criteria besides filter_hook
    - Its *what* attribute
    - Its *message_source* attribute
- BMessageQueue
  - Used by applications, *specifically their BLooper class*, to maintain a queue of messages to be processed
  - Also has methods for locking/unlocking the message queue besides the typical queue operations
  - Also has a method to search the message queue

The Application Kit

Class Inheritances



- The BHandler and the Blooper are in fact subclasses of BArchivable
- BArchivable class is what provides an interface for putting and extracting objects into message archives
- This provides the core of the functionality of sending objects between apps
- *Remember that every application typically has a BLooper (which sends/receives messages) and several BHandler's (which processes messages).*
- Here we see that a BLooper infact inherits from BHandler
  - Implies it can itself serve as a message handler if no specific handlers are required by the app OR
  - An app could chain together several handlers for its messages instead
  - This clever use of inheritance in their design lets the application writer leverage code reuse and modularity

The Application Kit

What a simple application looks like

```
#ifndef HELLO_WINDOW_H
#include "HelloWindow.h"
#endif
#ifndef HELLO_WORLD_H
#include "HelloWorld.h”
#endif
int main(int, char**)
{
   HelloApplication    myApplication;
   myApplication.Run();
   return(0);
}

HelloApplication::HelloApplication()
                : BApplication("application/x-vnd.Be-
HelloWorldSample")
{
   HelloWindow       *aWindow;
   BRect             aRect;

   // set up a rectangle and instantiate a new window
   aRect.Set(100, 80, 260, 120);
   aWindow = new HelloWindow(aRect);

   // make window visible
   aWindow->Show();
}
```

- We see here a part of a simple “Hello World” application
- It includes a BApplication class (*HelloApplication being a derivation of BApplication)*
- Calling the Run() method of a Bapplication object starts processing of any messages it receives
- This simple application doesn’t leverage the messaging system as it doesn’t need to talk to another app.
- It does give us an idea of how application code looks on Haiku (by leveraging system classes to access system services)
- *Link to more example code in the references section*

Scripting

- Every application *(BApplication)* can define its own scripted commands
- A set of these commands forms the applications interface to other applications who may wish to “script” the application
- Script commands are sent to an application using the infrastructure provided by the Messaging Kit
- Centers around the notion of
  - Commands: *What action to perform?*
  - Property: *What the command should act on within the app?*
  - Specifiers: *Used to target (specify) which instance of Property has to be targeted*
- Mechanism can be leveraged by apps written in any supported language. *Not easy to do on other Operating Systems.*

The Support Kit

- Provides a useful set of classes for the rest of the system API to use *(All other Kits and applications)*
- Can be considered as the “base” of what supports the rest of the system
- Provides classes towards the following functionality
  - Thread Safety
  - Thread Local Storage
  - Archiving and I/O
  - Memory Accounting and Management
  - Common Datatypes and Objects
  - Most of the error codes for the system

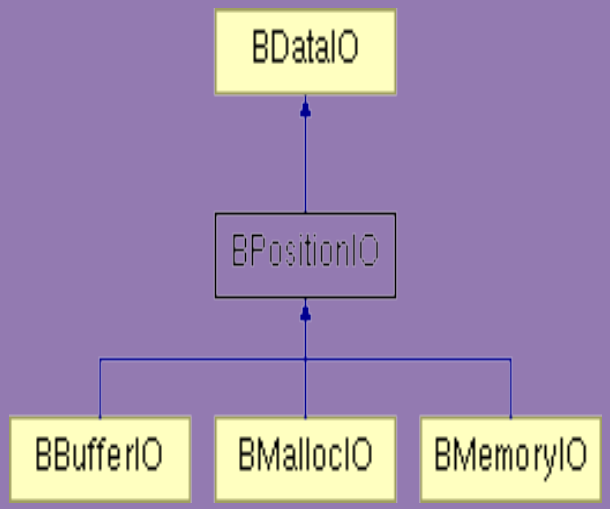
The Support Kit

A closer look at its classes

- BPositionIO
  - Actually inherits from BDataIO: Models a generic IO Stream
  - Provides advanced read,write and seek on top of BDataIO
  - It's the primary operand for most of the functionality some of the other kits *(ex. Translation kit which we'll see next)*
- BFile
  - This represents a file, actually inherits from BPositionIO
  - This makes the kit naturally extensible for dealing with files as sources and sinks of data
- BMemoryIO
  - Inherits from BPositionIO
  - Provides I/O functionality on exisiting memory
- BMallocIO
  - Also inherits from BPositionIO
  - Used to allocate a memory chunk based on a block size
  - Provides the position I/O interface to newly assigned memory
- BBufferIO
  - Provides a buffer *"adapter"* to a stream
  - Does NOT provide an entity to read/written to but a *"front-end"* to a IO Stream

The Support Kit

I/O Classes: Inheritances



- We see the use of inheritance in providing different behaviors
- The generic functionality is provided by BDataIO
- A more sophisticated mechanism is provided by BPositionIO
- Further derivations are used for similar objects that have slightly different semantics
- Care taken not to have a deep inheritance hierarchy

The Support Kit

Some more classes…

- BLocker
  - Provides a semaphore like mechanism for locking
  - Allows recursive locks
    - i.e A function that calls a lock() on a semaphore, calls another function that also calls lock() on the same semaphore
    - Possible because this object keeps track of number of locks from the same thread
  - Has a faster mechanism than conventional semaphores
    - Has checks to determine if acquiring lock is necessary
- BAutolock
  - Makes the use of a lock easier and less prone to programmatic errors
    - Provides a convenient mechanism to protect sections of code
  - Used in combination with a BLocker object to acquire lock
  - Created & used locally within a function: *created on the stack*
  - Therefore destroyed when leaving the function
  - As part of the object destruction, *lock gets released*

The Support Kit

Some more classes…

- BBlockCache
  - Creates and maintains a pool of memory blocks
  - Can be used in performance critical app sections
    - Memory allocation/release are expensive operations
    - *Instead:* have many blocks at our disposal and release them all later
- BStopWatch
  - A timer class, provides methods to time events
  - Designed to behave like a physical stop watch
  - Also useful in debugging code, like an inexpensive profiler
- Data Structures
  - Bstring
    - Class with extensive support for string operations
  - Blist
    - Generic ordered container to hold any kind of object type
    - Provides common access, modification, comparison methods
    - Grows and shrinks automatically depending on contents
    - No Memory Management Required by the app
  - … Several others *including basic data types and constants*

The Translation Kit

- The Translation Kit provides a framework for converting data streams between different formats
- Picture a word processor application importing and exporting documents in a variety of formats *(HTML, ASCII, PostScript)*
- Provides classes for applications to leverage this functionality *(and also extend it with add-ons)*
- Abstraction at the design level: Abstracts out format details for the application writer
- Inherently provides good opportunities for code reuse
  - *Example: A file format converter and file viewer can leverage the same code*

The Translation Kit

A closer look at its classes

- BTranslator
  - These is the superclass to extensible “add-ons” referred to earlier
  - Derived from this are the classes that does the conversions
  - Can be native or provided by a 3rd party
- BTranslatorRoster
  - Provides apps dependency resolution of translation modules (add-ons)
    - Services Provided
      - Provides Initialization *(ex. load this translator)*
      - Information *(ex. which translators are loaded)*
      - Translation *(choosing an appropriate translator and performing the translation)*
      - Configurations services *(changing behavior of a translator)*
- BTranslationUtils
  - Contains functions to load bitmap images from an IO Stream/File

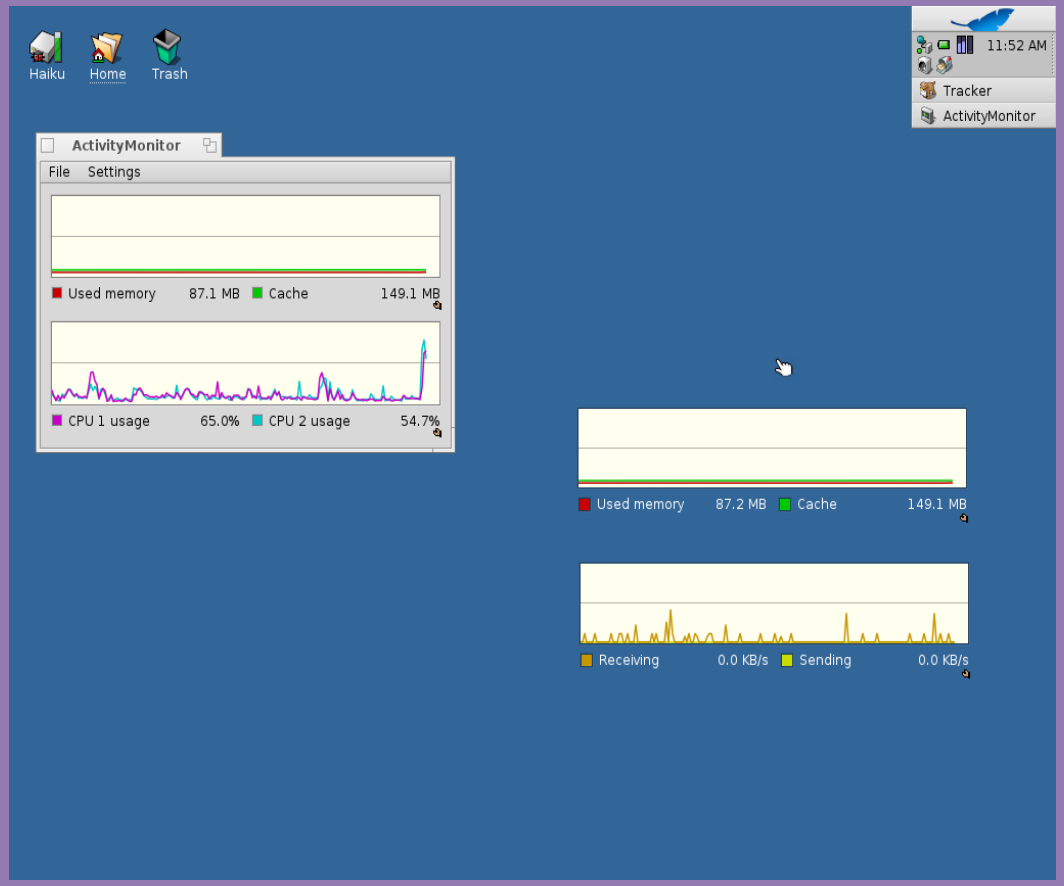
Interesting Features

Replicants

- Stepping back in granularity from classes
- Lets take a look at an interesting features in the Haiku resulting from it being Object Oriented
- Replicants are essentially an application instance that is launched *within* another application
- Its trick lies in the BView UI class *(from the Layout Kit)*
  - *BView represents the rectangular area of a Window*
- It has a function that allows it to Archive itself
  - Archive is an object that can be exchanged with other processes/ threads using the messaging infrastructure
- It also has a link to a BDragger class *(used as a handle to move the window)*

Interesting Features

Replicants…



- BShelf is a second class that enables replicants
- It's a specialized BView that can receive dragged and dropped BView objects *(Implemented as specialized messages)*
- Application is launched by one app calling the instantiate method of the archive of the other
- Helps integrating apps with one another
- Shows the power object oriented design for GUIs

Interesting Features

File System (OpenBFS)

- The journaling filesystem used to support Haiku
- Started as remnants of the BeOS File System (BFS)
- Has had several improvements since
- Upto x10 times faster than the original BFS
  - Uses a file cache in addition to a block cache
- Entirely written in C++
- OpenBFS developers claim it helped their development process
  - It resulted in cleaner code which was easier to understand
  - Easier to maintain the codebase
  - Made it easier for them to implement it a module at a time
  - It was also clear to them at the very start as to how they would integrate each developmental step into the project

Interesting Features

File System (OpenBFS)…

- The most unique feature of this file system is that it has a Transaction API : Database like file system
  - Supports queries run on the file system similar to a database, in addition to the typical file operations
  - You can also group multiple queries together
- Has an internal indexing mechanism on the metadata that enables very fast queries *(very fast file searches)*
- Allows users to extend attributes of any file *(like "artist" for an mp3 file)*
- Allows users to leverage indexing on any attribute
- All of this combined makes for very powerful search/query semantics
- User is able to do all this without having to write code. *Impressive!*

HAIKU

Where its headed

- Its far from complete. Several things planned for the near future.
- System Calls are much slower when compared to Linux/Unix
- Wide range of devices still not supported : Drivers
- Support for other file systems is still lacking
- Bugs exist in several Kits.
  - System and Applications crashes are still being resolved.
- More Apps need to be ported to HAIKU
- Size of the effort is not yet at the scale of Linux Kernel or comparable projects.
  - Some of the developers just haven't gotten around to these issues

Interested in learning more?

Head over to…

- Overview
  - http://en.wikipedia.org/wiki/BeOS
  - http://en.wikipedia.org/wiki/Haiku_(operating_system)
- Project Website: http://haiku-os.org/
  - Documentation section
  - Articles section
  - Plenty of other blogs *(ex. How to run Haiku on a VM and so on)*
- BeOS sample code:
  - http://www.haikuware.com/directory/start-download/development/sample-code/beos-r5-sample-code
  - Has code examples from every Kit (subsystem)
- BeBook:
  - http://www.haiku-os.org/legacy-docs/bebook/index.html
  - Excellent documentation of BeOS, most of which is still relevant to Haiku
- Lastly the HAIKU mailing list would be the best place to ask for anything you cant find in the above resources

Questions?

Thank You