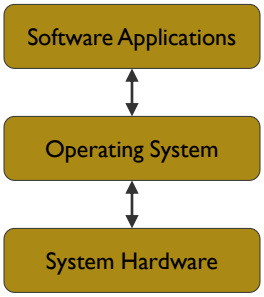
Symbian Platform Overview

Operating System?

- Software Program—Similar in this Sense to Other Programs
- Resource Encapsulation—Lens through which Users and Applications View System Resources like Hard disk, DVD drives, Networks.

Operating System?

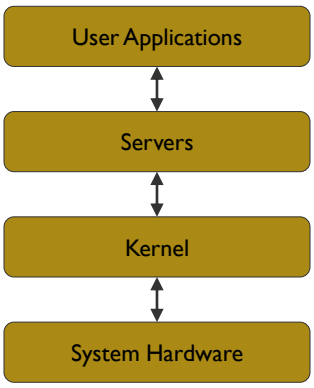
- Binds Hardware and Software Together



Operating System is Essential

Symbian OS—Overview

- Designed with Smartphones as the Target Platform in Mind
- Multitasking and Multithreading Supported
- Symbian OS Kernel is Microkernel
- Mobile Phone Manufacturers Buy Licenses of Symbian



Symbian OS—Layered Model

- Symbian OS is Structured in Layers
- Layers are Decomposed in Blocks and Sub-blocks
- Blocks and Sub-blocks are Decomposed in Components or Collection of Components
- Layers are Highest Level of Abstractions
- Components are Lowest Level of Abstractions
- Layers and Blocks are Logical Concepts
- Components are Physical Objects (Software Code)

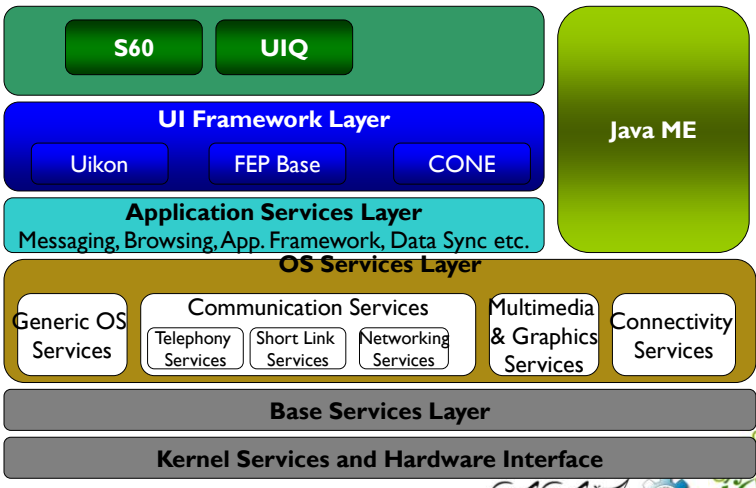
Symbian OS—Layered Model

- Layers
  - Each layer abstracts the functionality of the layer beneath and provides services to the layer above
  - Examples
    - OS Services Layer
    - UI Framework Layer
- Blocks
  - A block or sub-block roughly corresponds to a "Technology Domain"
  - Examples:
    - Telephony Services
    - Network Services
- Components
  - Components are the basic entities of the model
  - Common, Optional and Replaceable functionality is defined at Component Level

Symbian OS—Layered Model

- Symbian OS is Shipped in Headless Configuration
  - Minimal User Interface
  - Not Production Quality User Interface
- Mobile Phone Manufacturers Either
  - Develop their Own Production Quality User Interface or
  - License a Suitable User Interface
- Production Quality User Interfaces Already Developed:
  - S60 (Series 60)—Developed and Licensed by Nokia
  - UIQ—Developed and Licensed by UIQ Technology
  - MOAP (Mobile Oriented Application Platform)—Developed by FOMA (Freedom of Mobile Access) Consortium in Japan
  - Series 80 and 90—Developed by Nokia but not Licensed to Others


Symbian OS—Layered Architecture




Symbian Layers

- UI Framework Layer
- Application Services Layer
- OS Services Layer
- Base Services Layer
- Kernel Services & Hardware Interface Layer

(Book: Pg 14-15)

Symbian OS—Key Design Patterns

Localization Of Mobile Platforms : Pg 15

References

- The Symbian OS Architecture Sourcebook by Ben Morris
- Smartphone Operating System Concepts with Symbian OS by Michael J. Jipping


Symbian: Application Design and Architecture

(S60 Perspective)


Application Design: Typically MVC Pattern

- Model View Controller Architecture
  - Model (the Document—CEikDocument)
    - Contains and Manipulates Data of the Application
  - View (Application View—CCoeControl)
    - Displays Application State Based on Model Data
    - Receives User Input
    - Notifies Controller of Relevant Events
  - Controller (Application UI Controller—CEikAppUI)
    - Handles Application Events
    - Interacts with Model
    - Selects the View to be Displayed

Symbian Application Framework

- UIKON (Previously Called EIKON)
  - Main Component of "Application Framework"
  - Allows other GUI Frameworks to Run on Top of Symbian OS
    - S60
    - UIQ
- UIKON (Sub)Frameworks
  - CONE (Control Environment)
    - Framework for Graphical User Interface
  - APPARC (Application Architecture)
    - Framework for Applications and Application Data

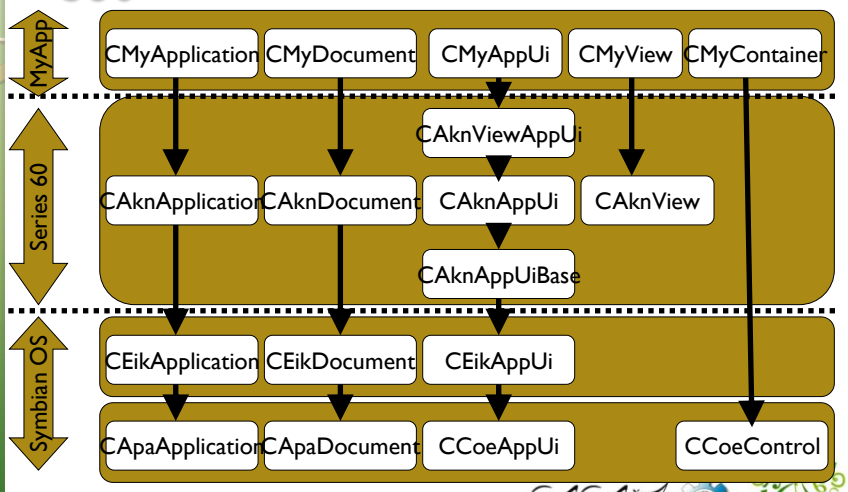
S60 and UIQ Platforms

- Extend the UIKON Framework by Adding Libraries Appropriate for each of Them
- S60 Library: Avkon (Class Prefix: CAkn)
- UIQ Library: Qikon (Class Prefix: CQik)

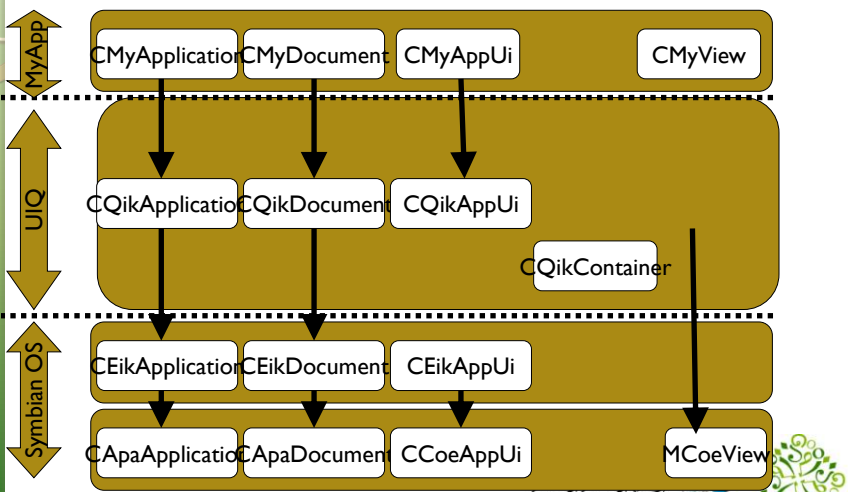
Application Components

- Application
- Document
- AppUI
- View

Application Structure Overview in S60



Application Structure Overview in UIQ



Application Entry Point

- Every Symbian Application must Implement Two Functions that are Called by the Framework to Launch the Application

```
LOCAL_C CApaApplication* NewApplication()
{
        return new CMyApplication;
}
```

```
GLDEF_C TInt E32Main()
{
        return EikStart::RunApplication( NewApplication );
}
```

Resources

- Resource Files are Used to Define:
  - User Interface Components
  - Visible Text

Resource Files

- Resource Files Contain:
  - GUI Element Definitions (Menus, Dialogs etc.)
  - Strings Needed by Application at Runtime
- Advantages
  - Make Source Code Shorter and Simpler
  - Save Memory because Text is Loaded only when Needed
  - Make Localization to Different Languages Easier

Resource File Structure

- Data Types
  - BYTE, WORD(2-bytes), LONG(4-bytes), DOUBLE(8-bytes)
  - LTEXT(A Unicode String with Defined Length)
  - BUF (A Unicode String)
  - LINK, LLINK(ID of Another Resource)

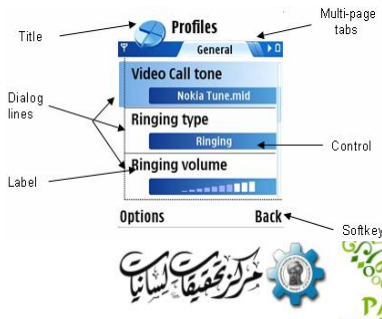
Resource File Structure

- Resource File Statement Types
  - NAME
  - STRUCT: Named Structure for Building Aggregate Resources
  - RESOURCE: Defines a Resource
  - ENUM/enum: Defines an Enumeration (Similar to C)

Resource File Structure

- STRUCT Statment
  - STRUCT Statements are Placed in Files with .rh (Resource Header) Extension

```
STRUCT DIALOG
{
        LONG flags=0;
        LTEXT title="";
        LLINK pages=0;
        LLINK buttons=0;
        STRUCT items[]; // an array
        LLINK form=0;
}
```



Resource File Structure

- RESOURCE Statement

```
RESOURCE DIALOG r messages_dialog
{
        title = "Title text";
        flags = EAknDialogSelectionList;
        buttons = R_AVKON_SOFTKEYS_OK_CANCEL;
        items =
        {
                DLG_LINE
                {
                        type = EAknCtSingleListBox;
                        id = EListControl;
                        control = LISTBOX
                        {
                                flags = EAknListBoxSelectionList;
                                array_id = r_message_list;
                        };
                }
        };
}
```

Resource Files: Bitmaps and Icons

- Application Icons are Stored in Bitmaps
- In Symbian, Multiple Bitmap Files are Stored in a Single File Called Multi Bitmap
- Bitmap Resources are Structure in Following Two Files
  - MBM (Multi Bitmap File)
  - MBG (Contains an ID for Each Bitmap in MBM)

Registration

- Applications are Required to be Registered with Underlying Platform
- File : <application_name>_reg.rss Contains Registration Information
  - UID of the Application
  - Name of Application Executable (without extension)
  - Application Properties (embedibility, hidden)


Localization

- Localization Files Contain "Local Language Strings"
- One Localization File is Produced for Each Language
- File : <application_name>.rls Contains Strings to be Localized


Project Specification File (MMP)

```
TARGET          MyApp.exe
TARGETTYPE      exe
UID             0x0100039CE
0xE3AA6613
SOURCEPATH      ..\src
SOURCE          MyApplication.cpp
SOURCE          MyAppView.cpp
SOURCE          MyAppUi.cpp
SOURCE          MyDocument.cpp

SOURCEPATH      ..\data

START RESOURCE  My.rss
HEADER
TARGETPATH      resource\apps
END //RESOURCE

START RESOURCE  My_reg.rss
TARGETPATH      \private\10003a3f\apps
END //RESOURCE
```

```
USERINCLUDE     ..\inc
SYSTEMINCLUDE   \epoc32\include
LIBRARY         euser.lib
LIBRARY         apparc.lib
LIBRARY         cone.lib
LIBRARY         eikcore.lib
LIBRARY         avkon.lib

LANG            01

VENDORID        0
SECUREID        0xEA7408AF
CAPABILITY      ReadUserData

START BITMAP MyApp.mbm
  HEADER
  TARGETPATH    \Resources\Apps
   SOURCEPATH    ..\images
   SOURCE   c24   image1.bmp
   SOURCE   c8    images2.bmp
END
```

Project Specification File

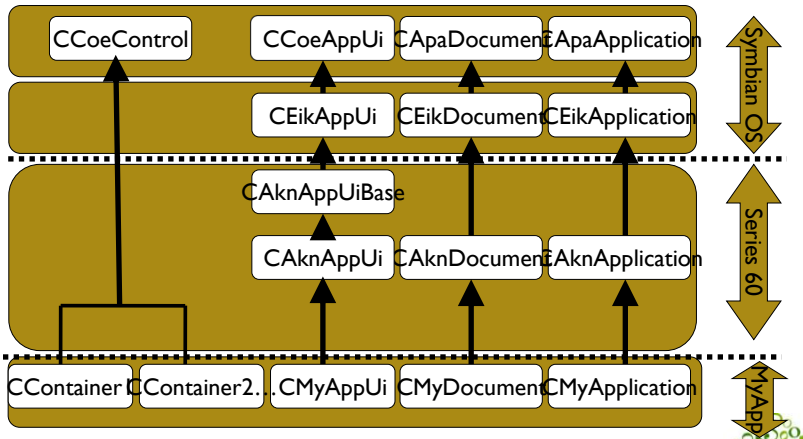
- UID Comprises 3 Components:
  - UID1: Same for All Binary Files and Automatically Supplied
  - UID2: Indicates the Type of Executable (0x0100039CE for Applications)
  - UID3: Uniquely Identifies the Application
- SECUREID
  - By Default Same as UID3
- CAPABILITY
  - Specifying the APIs that Application want to Access

Application Resource Files

File Name	Description
AppName.rss	Application's Resource Script
AppName_reg.rss	Application's Registration Information
AppName.rls or AppName.loc	Application's Localizable Strings
AppName.rsg	Generated Header Containing Symbolic Resource IDs
AppName.hrh	Enumerated Constants for Application's Commands
AppName.rsc	Generated Compiled Resource File

Application Architecture Possibilities

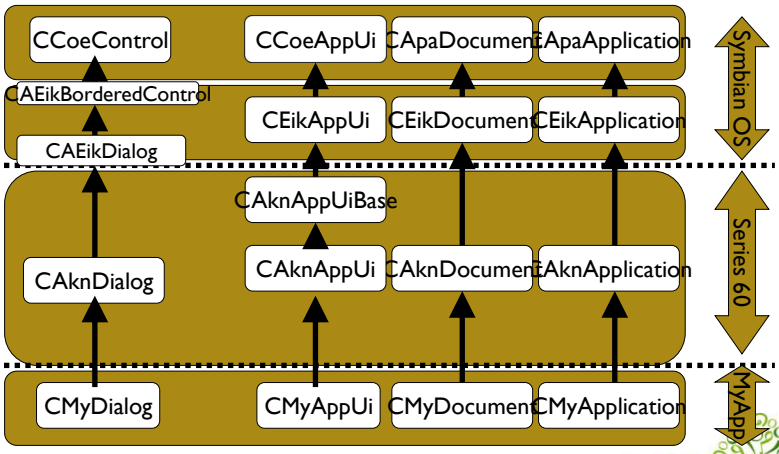
Traditional Symbian Control Based Architecture



Traditional Symbian Control Based Architecture

- Localization of Mobile Platforms (Pg 45)

Dialog Based Architecture



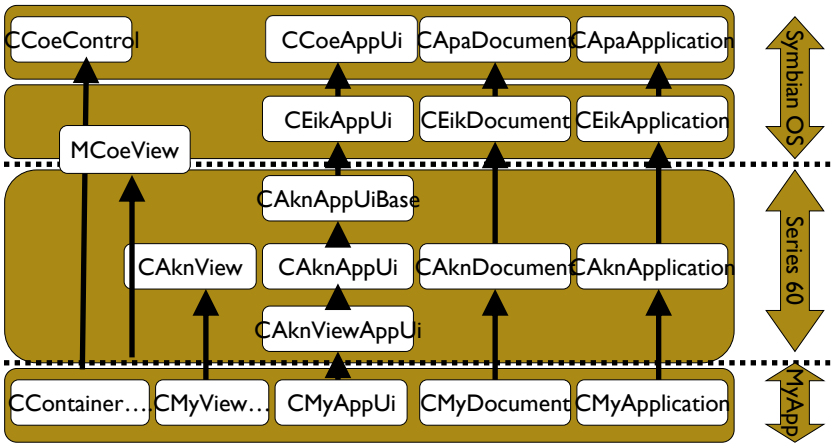
PAN Localization

Dialog Based Architecture

- *Localization of Mobile Platforms* (Pg 45)

PAN Localization

View Switching Architecture



References

- Symbian OS C++ for Mobile Phones by Richard Harrison and Mark Shackman
- S60 Programming by Paul Coulton and Reuben Edwards
- Developing Software for Symbian OS by Steve Babin
- The Accredited Symbian Developer Primer by Mark Jacobs and Jo Stichbury
- Mobile computing : technology, applications, and service creation by Asoke K. Talukder, Roopa R. Yavagal

Symbian: Application Development Concepts


Class Naming Conventions

- Class Names
  - Prefix+Class Name+Suffix
- C Classes (C is Prefix in Class Name)
  - Prefix 'C' Stands for 'Cleanup'
  - Derived Directly or Indirectly from CBase
  - Should be Constructed on Heap and Require Cleanup
  - Should Not be Constructed on Stack, Use Private/Protected Constructor to Prevent this
  - A Class can Only Inherit from a Single C Class
  - Example: CArray
- T Classes (T is Prefix in Class Name)
  - Also Called Data Type Classes
  - Encapsulates a Value of Specific Type e.g. TChar
  - Generally Do Not Use Dynamic Data i.e. Created on Stack but May also Use Heap if Required


Class Naming Conventions

- R Classes (R is Prefix in Class Name)
  - Also Called Resource ('R') Classes
  - Owns a Client Side Handle to a Resource, Resource is Actually Owned by a Symbian OS Server
  - Can be Instantiated on Heap or Stack
  - Example: RFile
- M Classes (M is Prefix in Class Name)
  - Also Called Interface Classes
  - Equivalent to an Abstract Class (Contains Pure Virtual Functions)
  - Used to Define Callback Interfaces
  - A Class can Inherit from Multiple M Classes
- Static Classes (No Prefix Attached to Static Classes)
  - Contains Only Static Functions
  - Cannot be Instantiated into an Object

Symbian Data Types (e32defs.h)

Data Types	Symbian OS
Integer	TInt, TInt64, TInt32, TInt16, TInt8
Unsigned Integer	TUint, TUint32, TUint16, TUint8
Float	TReal, Treal64, Treal32
Character	TText, TText16, TText8, TChar
Boolean	TBool
void*	TAny*, (Can Point to a Function as Well)

Exception Handling

- Standard C++ Exception Handling in Symbian OS v9 (try/catch mechanism)
- Exceptions for Previous Symbian OS (before OS v9) are "Leaves"
  - Leaves are Alternative to C++ Exceptions


Exception Handling

- Exceptions or Leaves
  - Runtime Errors that are not Programmer's Fault
  - Examples: Lack of Memory, Inability to Open Network Connection
- Panic
  - A Programming Error
  - Generally, an Application is Terminated in Case of Panic
  - Panics Cannot be Caught and Handled
  - Examples: Out of Bounds Array


Exception Handling: Leaves

- A Leave
  - Suspends Code Execution at the Point where Leave Occurs
  - Resumes Execution where Leave is "Trapped"
- Leaves May Occur while Performing Operations that May not Succeed
  - Allocation of Memory
  - File Creation
- Traps are used to Catch Leaves and Allow them to be Handled
- Functions that May Leave have "L" as Suffix in their Name


Why Do Leaves Occur?

- Calling a Leaving Function
- Use of Overloaded new (Eleave) Operator when Memory Allocation Fails
- Use of Explicit Leave [Similar to C++ Throw]
  - User::Leave()
  - User::LeaveIfError(TInt)
  - User::LeaveNoMemory()
  - User::LeaveIfNull()


How Leaves are Trapped?

- If a Function may Leave, it is Called Like This
  - TRAPD(error, FunctionMayLeaveL());
    - **OR**
  - Tint error;
  - TRAP(error, FunctionMayLeaveL());


Cleanup Stack

- Cleanup Stack is Crucial to Symbian Memory Management
- Used to Ensure that if a Leave Occurs, there are No Memory Leaks
- Cleanup Stack is Used to Store Pointers that may Become Orphaned if a Leave Occurs


Cleanup Stack Rules

- Any Locally Scoped Pointer to a Heap-Allocated Object must be Pushed onto the Cleanup Stack if there is a Risk of a Leave Occurring and there is no other Reference to the Object Elsewhere
- Instance Data (data owned by an instance of a class) Must Never be Pushed onto the Cleanup Stack


Cleanup Stack Functions

- To Push a Pointer on Cleanup Stack
  - CleanupStack::PushL(aPointer)
- To Pop a Pointer from Cleanup Stack
  - CleanupStack::Pop(aPointer)
- To Pop Multiple Items
  - CleanupStack::Pop(aCount, aPointerToLastExpectedItem)
- To Pop and Destroy
  - CleanupStack::PopAndDestroy(aCount, aPointerToLastExpectedItem)


2-Phase Object Construction

- Object Construction Steps on Heap
  - Step-1: Allocate Required Memory on Heap
  - Step-2: Execute Constructor of the Allocated Object
- What if Step-1 Succeed, and Step-2 Fails?
  - Allocated Memory will be Orphaned
- Solution
  - Perform Construction of Complex Objects in Two Phases


2-Phase Object Construction

- Make All Constructors Private or Protected
- Provide Static Factory Function(s) to Create Objects in Following Steps:
  - Allocate Memory on Heap Using Almost an Empty Constructor i.e. a Constructor that Cannot Leave
  - Push the Allocated Object Pointer on Cleanup Stack
  - Perform Construction of the Object Data
  - Pop the Allocated Object Pointer from Cleanup Stack


2-Phase Object Construction

- Tips
  - Constructors and Destructors Must Never Leave
  - Destructors Must Never Assume that Construction was Done in Full


2-Phase Object Construction Mechanism

- **new:** Almost Never Used. Used when Constructing a New Instance of an Application
- **new (ELeave):** Used when Constructing a Heap-Allocated Instance of a Class
  - **NewL():** Used when Constructing a Heap-Allocated Instance of a Compound Class [Cleanup from Cleanup Stack is Not Needed]
    - Instance is Either Directly Assigned to Member Pointer of Another Class Object OR
    - There is No Danger of a Leave before the Object is Deleted
  - **NewLC():** Used when Constructing a Heap-Allocated Instance of a Compound Class [Cleanup from CleanupStack is Needed]
    - Instance is Assigned to a Locally Scoped Pointer and there is a Danger of a Leave before the Object is Deleted

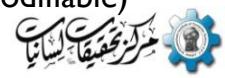

References

- Mobile computing : technology, applications, and service creation by Asoke K. Talukder, Roopa R. Yavagal
- S60 Programming by Paul Coulton and Reuben Edwards
- Developing Software for Symbian OS by Steve Babin
- The Accredited Symbian Developer Primer by Mark Jacobs and Jo Stichbury
- Developing Series 60 Applications: A Guide for Symbian OS C++ Developers by Leigh Edwards
- http://www.symbian.com
- http://www.forum.nokia.com

Symbian: Application Development Concepts

Descriptors

- Descriptors in Symbian OS are Similar to Strings
- May Contain Text and Binary Data
- TPtr8—8 bit Characters—Narrow Descriptors
- TPtr16—16 bit Characters—Wide (Unicode) Descriptors
- Descriptors Can be
  - Constant (Contents are Constant)
  - Modifiable (Contents are Modifiable)

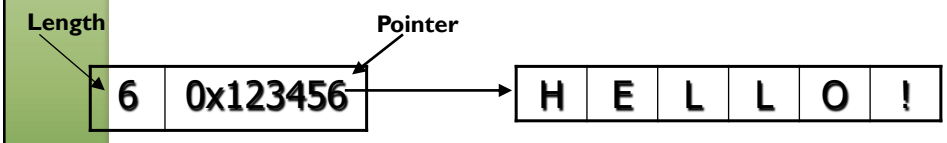



Descriptors

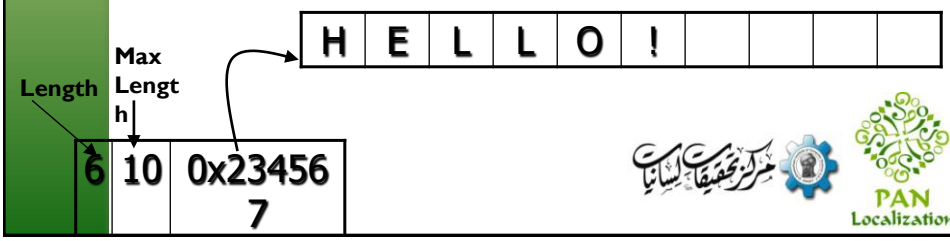
- Descriptors have an iLength Member that Stores the Current Length of the Descriptor
- Descriptors can Work without Null Termination
- Modifiable Descriptors also have an iMaxLength Member
- An Attempt to Increase the Length of the Descriptor beyond the Maximum Length will Result in an Immediate Panic


Pointer Descriptors

- Can Point to Text on the Heap, or Stack
- Constant: TPtr**C**



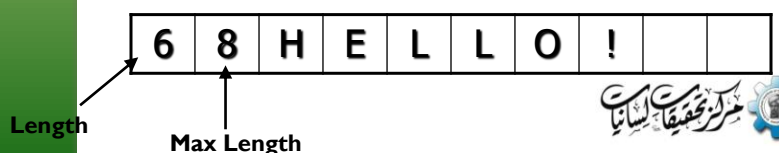
- Modifiable: TPtr



Stack Based Buffer Descriptors

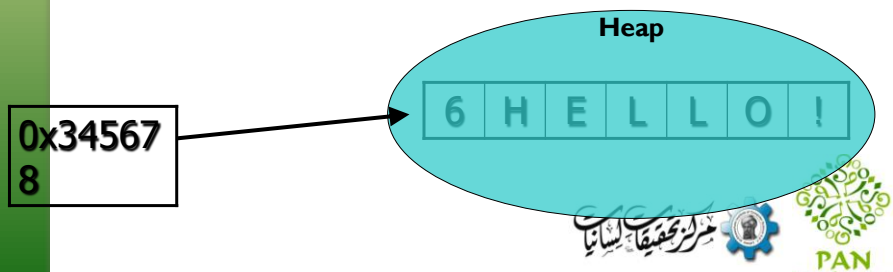
- Useful for Relatively Small Size of Data
- Directly Contain Data (as Part of Descriptor Object)
- Constant: TBuf**C**<6>

- Modifiable: TBuf<8>



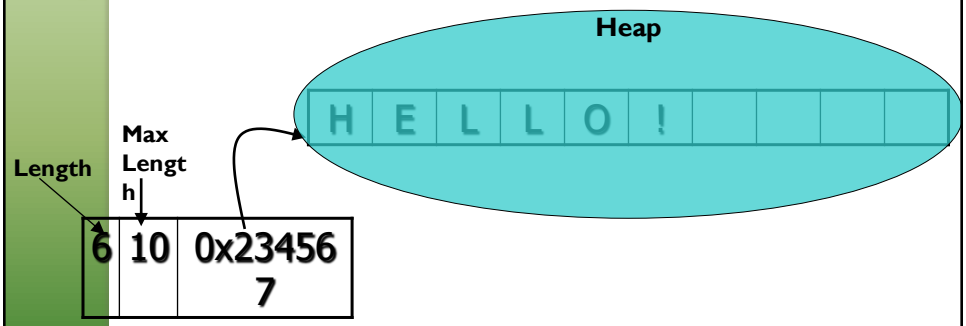
Dynamic Descriptors (Heap Based)

- Can be Used for Strings
  - That are Too Big to be Placed on Stack
  - For Which Size is Not Known at Compile Time
- Constant: HBuf**C**



Dynamic Descriptors (Heap Based)

- Modifiable: RBuf



String Literals

- Literals are Strings, Generally Used for Printable Text in the Program
- Literals are of Type TLitC, TLitC8, TLitC16
- String Literals are Constructed using the _LIT Macro
  - _LIT(KText, "Hello World");
  - Where KText is Name of String Literal (i.e. variable name)


Collection Classes: Arrays

- RArray
  - An Array of Fixed Length Objects
  - Size of One Array Element can Not Exceed 64o Bytes
- RPointerArray
  - An Array of Object Pointers


Collection Classes: Arrays

- CArray
  - Use Buffers to Store Data
  - Flat CArray
    - Store Entire Data in a Single Heap Cell
    - Once Full, any Append Operation Requires a New Heap Cell to be Allocated that is Large Enough to Contain the Original and New Data
- Segmented CArray
  - Store Data in Doubly Linked List of Smaller Segments
  - Each Segment is a Separate Heap Cell of Fixed Size

Asynchronous Services

- All System Services are Provided through Servers
- Servers Operate in their Own Processes
- Service Provider APIs Typically have Asynchronous and Synchronous Versions of their Functions
- Service Request Function Returns Immediately, while the Request itself is Processed in the Background.
- Relevant Processes are Notified when Request is Complete

Asynchronous Services and Active Objects

- Symbian Allows Application Programs to Create Threads
- Multiple Asynchronous Services can be Accessed using Multiple Threads
- However, Symbian Recommendation is to Use Active Objects where Possible, as an Alternative Option

Active Object Framework

- Active Object Framework
  - Active Objects
  - Active Scheduler
- Active Object Framework is Used for Event Driven Multitasking
- Active Scheduler Maintains a List of Active Objects which have Made Request for an Asynchronous Service

Active Object

- Implement 'Asynchronous Service Requesting Objects' as an Active Object
- An Active Object:
  - Requests an Asynchronous Service and
  - Handles the Resulting Completion of Event Sometime After the Request.
  - May Ask to Cancel a Request
  - Is Listed with Active Scheduler


Active Scheduler

- When Asynchronous Service Completes, It Generates Events to Notify Active Scheduler
- Active Scheduler
  - Detects Service Completion Events
  - Determines Associated Active Object
  - Calls the Active Object to Handle the Event.


Submitting an Asynchronous Request

- Each Active Object Can Only Have One Outstanding Request
- If a Request has Already been Placed by an Active Object, a New Request may Result in
  - Panic
  - Refuse
  - Cancel Outstanding Request and Submit New One


Active Object Event Handling

- Active Object Implements the Event Handling Function
- Active Object Event Handler is the Function for Handling Completion of Asynchronous Call
- Active Object Handler is Not Pre-Empted
- Control Returns to the Active Scheduler When Event Handler Returns
- If Multiple Requests are Completed, Control Returns to the Scheduler, they are Handled Sequentially in Order of their Priority
- Active Scheduler Calls the Event Handling Function of Associated Object


Active Object Structure: Key Elements

- **iStatus:** Data Member Representing Request Status.
- **R-Class Object:** A Handle on the Asynchronous Service Provider (usually an R-class object).
- **Connection** to the Asynchronous Service Provider.
- **Function** to Issue the Asynchronous Request
- **RunL():** Handler Function to be Invoked by the Active Scheduler when Request Completes
- **Cancel():** Function to Cancel an Outstanding Request

Active Object Implementation

- Create a Class Derived from CActive
- Create Asynchronous Service Provider Handle (R-Classes) as a Data Member in the Class
- Invoke Constructor of CActive, Specifying Object Priority
- Connect to the Service Provider in ConstructL() Method
- Invoke CActiveScheduler::Add() in ConstructL()
- Implement NewL() and NewLC()
- Implement Asynchronous Request Function that Calls the Service, Specifying iStatus as the Argument.
- Call SetActive()

Active Object Implementation

contd..

- Implement RunL() Method to Handle Necessary Work Once the Request is Complete
- Implement DoCancel() to Handle Request Cancel Operation.
- Implement RunError() to Handle any Leaves from RunL().
- Implement the Destructor to Call Cancel() and close the Handle(s) on the Service Provider(s).

Using Active Object

- Instantiate using NewL() or NewLC() as Appropriate
- Call Start(), to Make the Initial Request
- To Cancel the Request Prior to Completion, Call Cancel().

Active Objects: CActive Structure

```
class CActive : public CBase {
public:
   IMPORT_C virtual ~CActive();
   IMPORT_C void Cancel();
   inline TBool IsActive() const;
   inline TInt Priority() const;
protected:
   IMPORT_C CActive(TInt aPriority);
   IMPORT_C void SetActive();

  //  Implements cancellation of  outstanding request. This function is called as part of the active object's
Cancel().
   virtual void DoCancel() =0;
   // Handles an active object's request completion event. A derived class must provide an implementatio
  handle completed request. The function is called by active scheduler when a request completion event
occurs.
    virtual void RunL() =0;
    virtual TInt RunError(TInt aError);  //Called by Active Scheduler if RunL() Leaves

public:
   //Represents the status or error code returned by the asynchronous service provider.
   TRequestStatus iStatus;
private:
   TBool iActive;

};
```

Active Objects: Implemented CFileLoader

```
class CFileLoader : public CActive
{
public:
   void Start();
private:
   CFileLoader();
   void ConstructL(const TDesC& aFileName);
   void RunL();
   TInt RunError(TInt aError);
   void DoCancel();
private:
   TFileName iFileName;
   RFile iFile;
};
```

ECOM

- ECOM is a Generic and Extensible Framework by which Abstract Interfaces can be Defined and their Implementations Identified, Loaded and Managed.
- ECOM is A Mechanism to Extend Symbian OS

ECOM

- What ECOM Does?
  - **Identification:** Identifies all the Concrete Implementations of an Interface.
  - **Resolution:** Allows the Client to Choose the Implementation to be Used
  - **Instantiation:** Instantiates an Instance of the Concrete Class which Implements that Interface

ECOM (EPOC Component Object Model)

- ECOM Architecture is Used Transparently by Clients
- ECOM Server Manages Requests to Instantiate Concrete Instances of an Interface.
- ECOM Server Maintains a Registry of All Interface Implementations Installed on Device


ECOM Plug-in Interface Characteristics

- Standard Definition Functions
  - Abstract Class that Defines a Set of One or More Pure Virtual Functions
  - Concrete Classes Implement these Virtual Functions
- 1 or More Factory Functions
  - Used to Allow Clients to Instantiate an Interface Implementation Object
- Release Function
  - Used to Delete / Release Plugin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