Developing Secure Web Applications for Constrained Devices

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What is Security?

"Preventing adverse business consequences from the illegitimate actions of human beings."

Whitfield Diffie,
Chief Security Officer, Sun Microsystems

- Availability, reliability, robustness
- Integrity, authenticity, access control
- Secrecy, confidentiality, privacy

Impact of Device Constraints

- Possible constraints: CPU, memory, power, screen size, network bandwidth and latency
- Influence choice of algorithms and protocols, feature richness, user interaction (can impact security!)
- Workarounds: offload computation, new algorithms, feature profiling, caching/reuse, other clever implementation optimizations

J2ME™ Market Penetration

- 10 million Java enabled (J2ME) phones in Japan. Nextel sold 1.3 million Java phones in North America. Nokia expects to sell 50 million Java phones in 2002.
- J2ME will be leveraged by 70% of the smart phones PDAs by 2004 (Gartner group, Nov. 2000)
- 680 million Java enabled mobile devices worldwide by 2004 (ARC Group, June 2000)

Java™ 2 Platform Overview

Java 2 Enterprise Edition (J2EE™)

Java 2 Standard Edition (J2SE™)

Java 2 Micro Edition (J2ME™)

Java Card

Java Platform

HotSpot™ | CVM | KVM | Card VM

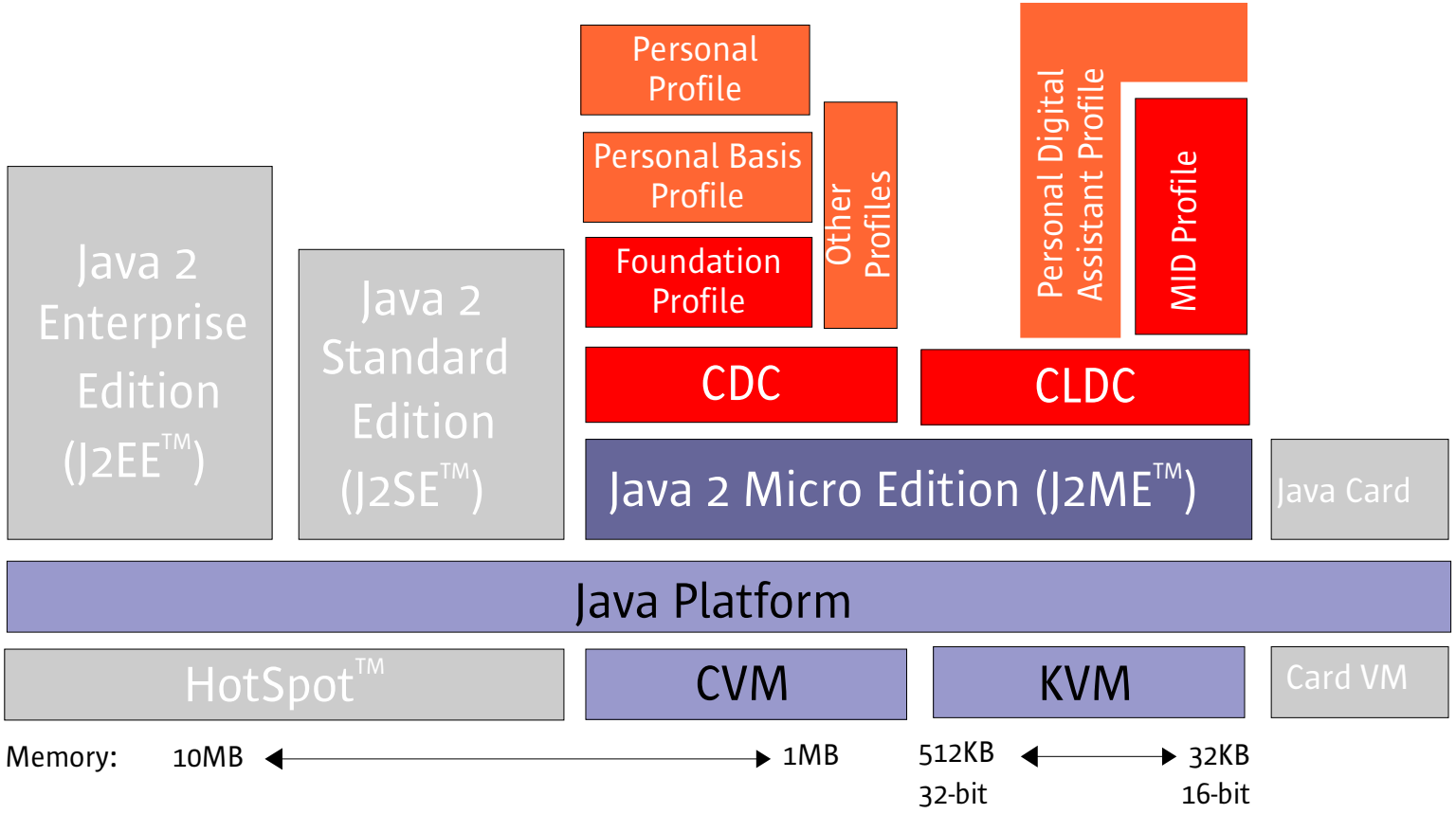
Memory: 10MB ◄——► 1MB | 512KB ◄——► 32KB

64-bit | 32-bit | 16-bit | 8-bit

Java™ 2 Platform Micro Edition

- *The* standard for development on a wide range of consumer electronics and embedded devices
- Consists of VMs and core APIs ("Configurations") plus application- and market-specific APIs ("Profiles") defined through Java Community Process (JCP℠)

J2ME™ Technology Overview



CLDC: Connected Limited Device Configuration
MID: Mobile Information Device

CDC: Connected Device Configuration

J2ME™ Availability

Technology	Type	Spec	Stage
CLDC 1.0	J2ME Config.	JSR-30	Final
MIDP 1.0	CLDC Profile	JSR-37	Final
CDC 1.0	J2ME Config.	JSR-36	Final
Foundation	CDC Profile	JSR-46	Final
RMI	CDC Profile	JSR-66	Proposed final
CLDC 1.1	J2ME Config.	JSR-139	Public review
MIDP 2.0	CLCD Profile	JSR-118	Public review
Personal Basis	CDC Profile	JSR-129	Public review
Personal	CDC Profile	JSR-62	Public review
PDAP	CLDC Profile	JSR-75	Community review

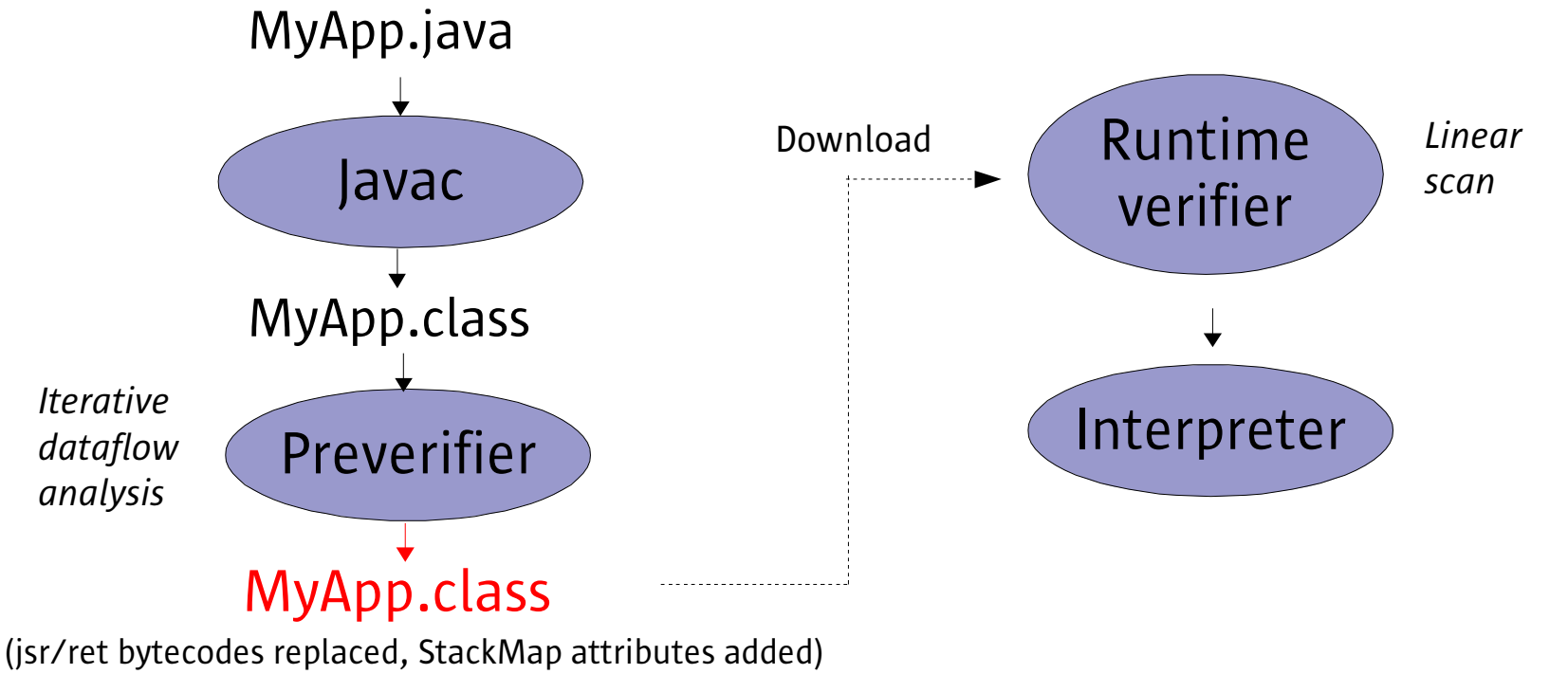
CLDC Security

- Low-level virtual machine security
  - Ensures applications cannot harm device
  - Classfile verification rejects invalid classfiles
- Application-level security
  - Controls access to external resources, e.g. files
  - Simple sandbox model
- End-to-end security mechanisms are out of scope (left for Profiles)

CLDC Classfile Verification

Development Workstation

Target device



(jsr/ret bytecodes replaced, StackMap attributes added)

CLDC Sandbox Model

- Requires classfiles properly verified and guaranteed to be valid Java applications.
- Programmer cannot override, modify or add system classes or modify/bypass VM's standard class loading mechanism.
- Only a limited, predefined set of APIs available to application programmer.
- Set of native functions is closed (no JNI).

CLDC Generic Connection

- Framework provides coherent, flexible, extensible support of different networking and I/O protocols. Follows URI syntax (RFC2396)
  - Connector.open("<protocol>:<address>;<parameters>");
- Profiles determine supported protocols:
  - Connector.open(file:///CFCard/newfile.txt");
  - Connector.open("http://www.sun.com");
  - Connector.open("socket://128.226.3.29:8080");
  - Connector.open("comm:COM1;baudrate=9600");

MIDPv1.0 Security Features

- No additional low-level or application-level security features beyond CLDC.
- No end-to-end security mechanism mandated -- but MIDP Reference Implementation (RI) 1.0.3 from Sun provides https support using KSSL*.

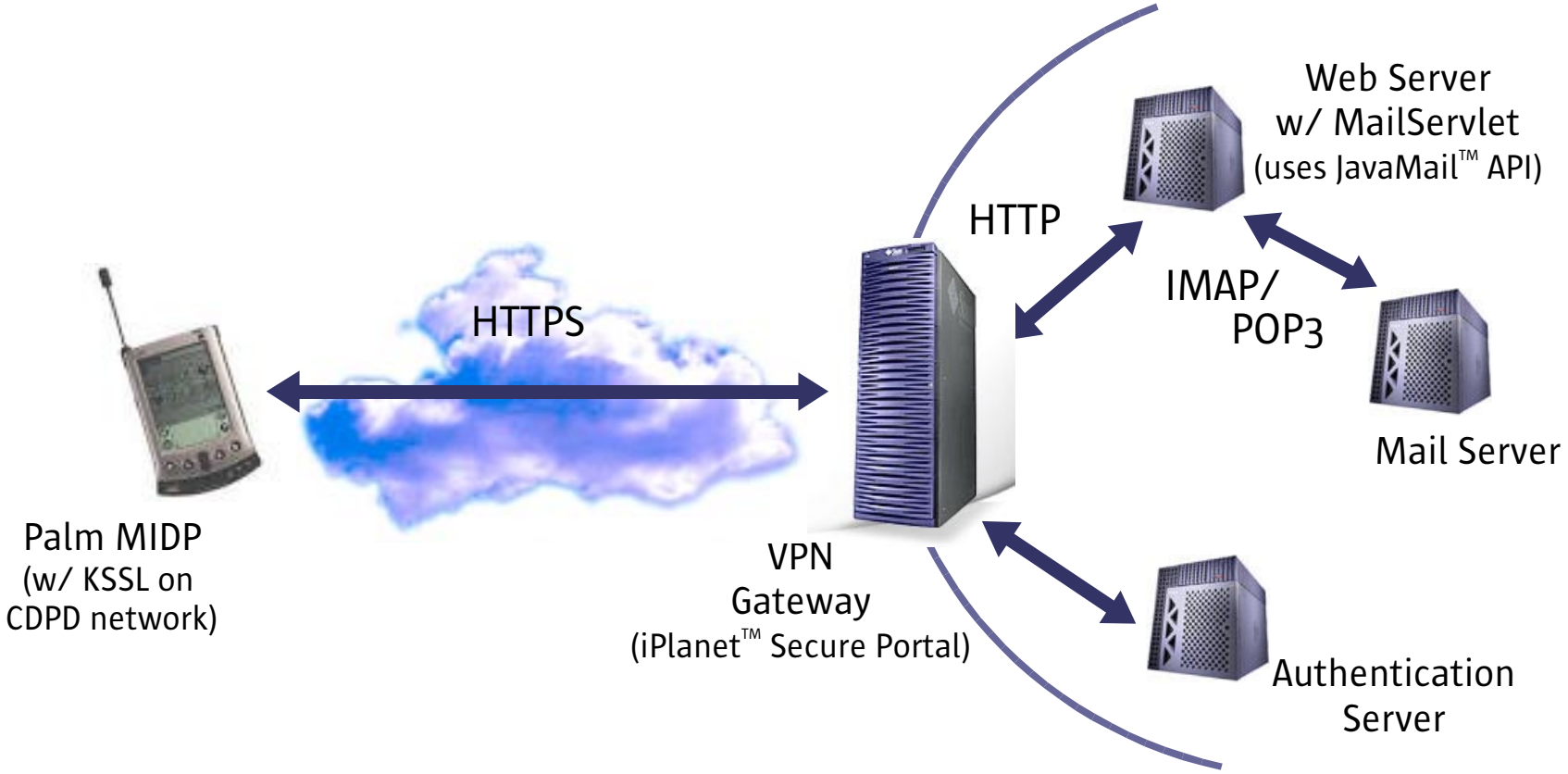
*Sun Labs research project, see http://playground.sun.com/~vgupta/KSSL

MEKeyTool

- Manipulates the set of trusted root certificates in MIDP-RI from Sun
- Based on J2SE™ keytool and described in tools/com/sun/midp/mekeytool/package.html
- Example usage: list trusted root certificates

```
$ java –classpath bin/MEKeyTool.jar
 com.sun.midp.mekeytool.MEKeyTool
–list –MEkeystore appdb/_main.ks
```

Example Application

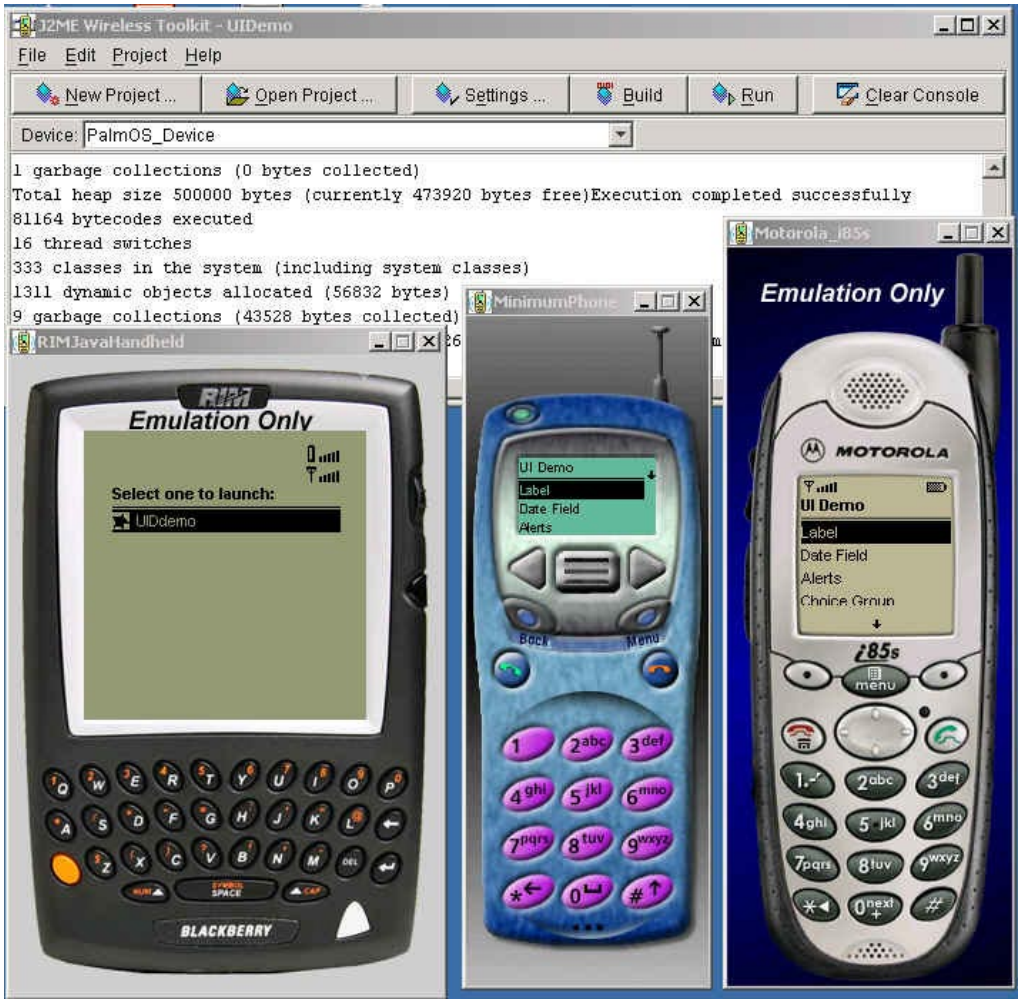


- Secure access to enterprise email.

MIDlet Development Steps

- Write your J2ME application
- Compile it
- Preverify it
- Package it into a JAR file
- Create the application descriptor (JAD)
- Deploy and run on emulator or device

J2ME™ Wireless Toolkit



- Comprehensive development environment -- standalone or with Forte™ for Java.
- Free download!
- Supports multiple device skins
- Integrable with third party IDEs

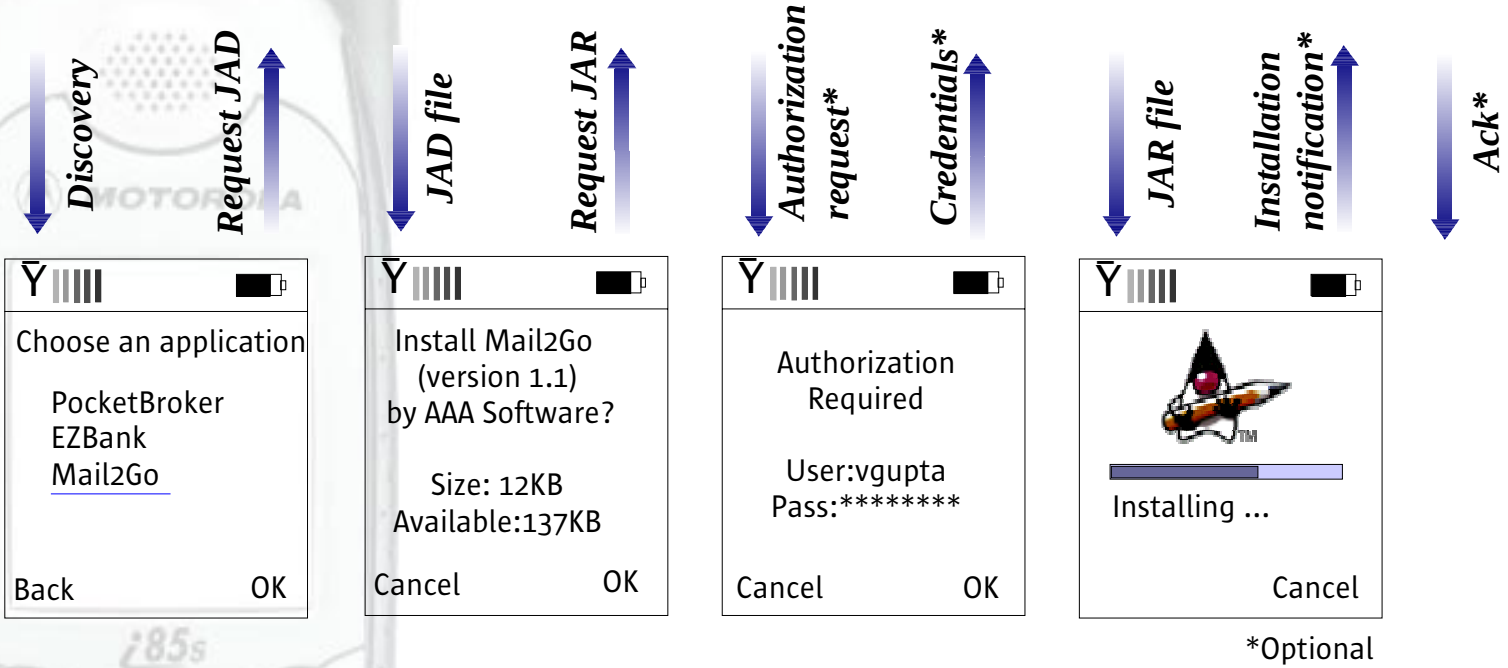
Sample JAD file

MIDlet-Name*: SunNet
MIDlet-Version*: 1.4
MIDlet-Vendor*: Sun Labs
MIDlet-Description: Mobile access to enterprise applications
MicroEdition-Profile: MIDP-1.0
MicroEdition-Configuration: CLDC-1.0
MIDlet-1: Configure,,net.sun.Configure
MIDlet-2: Login,,net.sun.Login
MIDlet-3: Nametool,,net.sun.Nametool
MIDlet-4: Caltool,,net.sun.Caltool
MIDlet-5: Mailtool,,net.sun.Mailtool
MIDlet-6: Logout,,net.sun.Logout
MIDlet-Jar-URL*: http:// ... /sunnet.jar
MIDlet-Jar-Size*: 38149
MIDlet-Data-Size: 1024

**Required*

- Used by App. Mgmt Software (AMS)
- Same format as JAR manifest.
- MIME type:
  text/vnd.sun.j2me.app-descriptor

Over The Air Provisioning



*Optional

- Application Management Software (AMS) uses HTTP 1.1 functionality for network interaction. Session management addresses privacy concerns.
- MIDlet suite is the unit of installation or deletion. Notification supported for both operations. Installation or update is “atomic”.

MIDPv2.0 Security Features

- Extends Sandbox model: trusted MIDlets can access restricted APIs
- Provides mechanisms for secure network communication -- ensuring source authentication, integrity and confidentiality of data

Signed MIDlets

- New attributes for JAD file, both use Base64 encoded values:
  - MIDlet-Certificate-*n*-*m*: *certificate*
  - MIDlet-Jar-RSA-SHA1: *signature*
- Device verifies signer certificate using configured root certificates and validates signature on JAR file.

Signature	*Verification*	*Action*
Absent	–	May install as untrusted
Present	Fails	Do not install
Present	Succeeds	Install as trusted

MIDlet Access Control

- Untrusted MIDlet suites
  - No access to protected functions or through explicit user permission
- Trusted MIDlet suites
  - Request named permissions with:
    - MIDlet-Permissions (critical)
    - MIDlet-Permissions-Opt (non-critical)
  - Device enforces access control in accordance with policy

Permissions

- Named by restricted APIs, names are hierarchical, share package name with API
- Granted with *User* input or *Allowed* unconditionally

Permission	*Protocol*
javax.microedition.io.Connector.http	Http
javax.microedition.io.Connector.https	Https
javax.microedition.io.Connector.datagram	Datagram
javax.microedition.io.Connector.datagramreceiver	Datagram server
javax.microedition.io.Connector.socket	Socket
javax.microedition.io.Connector.serversocket	Server socket
javax.microedition.io.Connector.comm	Serial port
javax.microedition.io.PushRegistry.datagram	Datagram
javax.microedition.io.PushRegistry.socket	Socket

User Permissions

- Requires explicit user approval
- Grant types
  - Blanket: valid until revoked or MIDlet deletion
  - Session: valid until MIDlet suite terminates
  - Oneshot: valid for single invocation of restricted method

Example Policy

domain: operator
grant: javax.microedition.io.Connector.socket
user: javax.microedition.io.Connector.comm

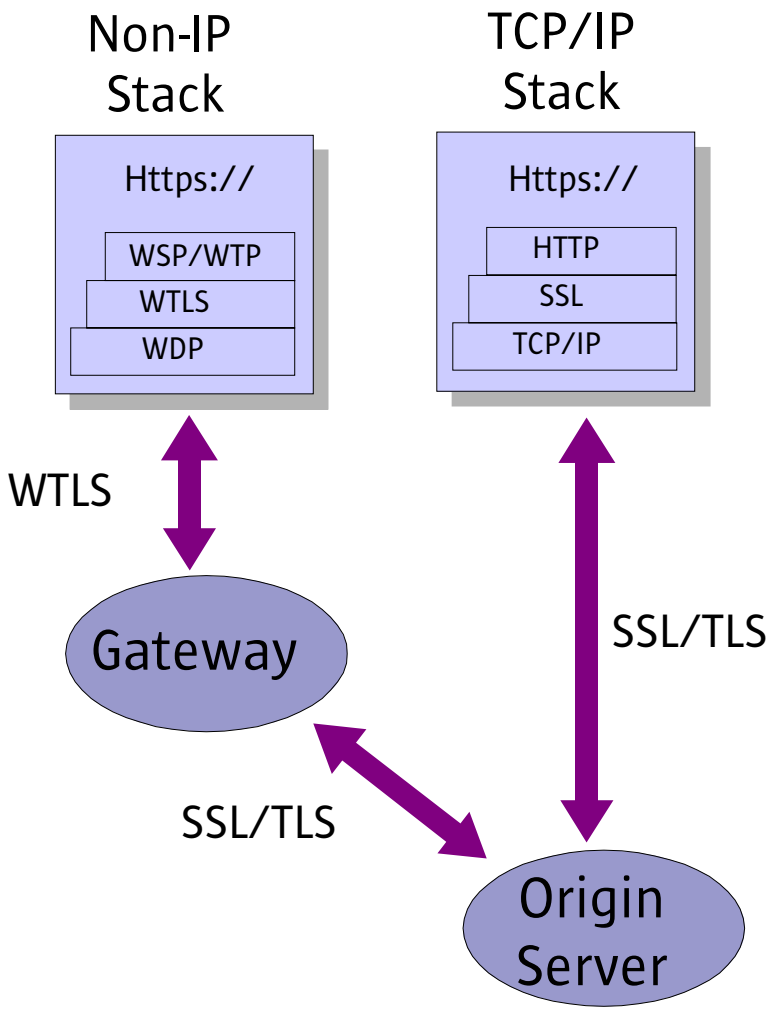
alias: lots_of_stuff
permissions: java.microedition.io.Connector.socket,
javax.microedition.io.PushRegistry

domain: manufacturer
grant: lots_of_stuff

Secure Networking

- HTTPSConnection
  - Secure HTTP over SSLv3.0 or TLSv1.0 or WTLS
- SecureConnection*
  - Secure socket connection using SSLv3.0 or TLSv1.0
- SecurityInfo
  - Access to server certificate and other secure connection parameters, e.g. Cipher suite, protocol name and version
- Certificate
  - Access to server identity and other certificate parameters
- CertificateException
  - Exceptions for certificates and connection setup errors

HTTPS & Secure Connection



- Like HTTP, HTTPS may or may not use IP-based transport.
- SecureConnection is truly end-to-end.
- Other application protocols (e.g. IMAP) can be layered atop SecureConnection

Security and Trust Services API for J2ME™

- Brand new JSR-177 for integration of a “security element”, e.g. smart cards
  - Secure storage for private keys, root certificates, personal information etc.
  - Cryptographic operations
  - Support services such as user authentication, banking, payment, digital rights management
  - Expected standardization: first half of 2003

Developer Resources

- Wireless Developer Homepage
  - http://wireless.java.sun.com/
- J2ME™
  - Homepage (http://java.sun.com/j2me)
  - Wireless Toolkit (http://java.sun.com/products/j2mewtoolkit)
  - Bill Day's J2ME Archive (http://www.billday.com/j2me)
- Java Community Process (JCP℠) Homepage
  - http://www.jcp.org/

The Takeaway

J2ME™ technology offers a comprehensive framework for developing and deploying secure applications on constrained devices.

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http://java.sun.com/

Sun microsystems

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J2EE™ Client Provisioning

- The J2EE Client Provisioning Specification (JSR-124) will provide a standard for partitioning server applications that provision client applications.
- The expert group is studying schemes used to provision content built for: J2ME MIDP, NTT DoCoMo iAppli, etc

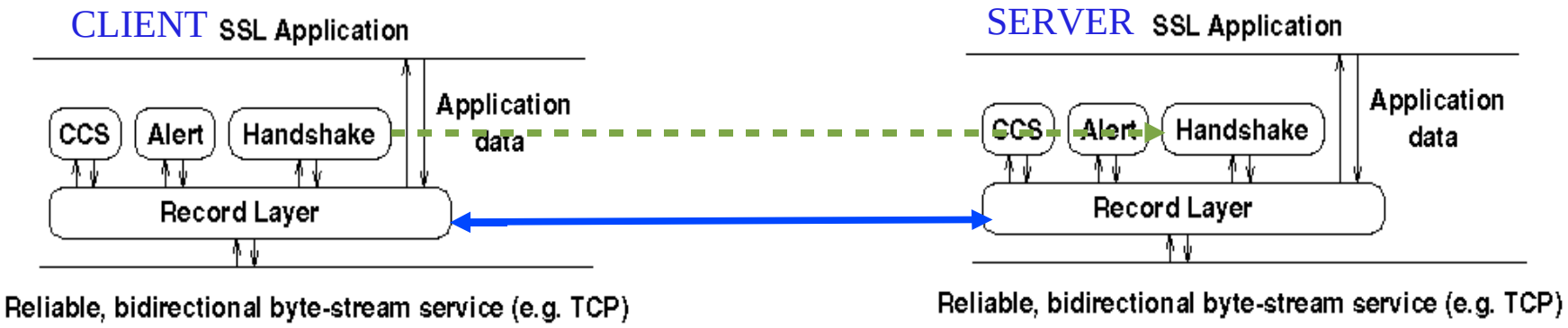
Crypto Building Blocks

- Shared Secret (aka symmetric-key) Cryptography: One key, two operations inverses of each other (RC4, 3DES)
  - Fast, Requires pre-determined shared secret key
- Public Key (aka asymmetric-key) Cryptography: One operation, two mathematically inverse keys (RSA, DH, DSA)
  - Only private key needs to be kept secret, public key only needs to be authenticated
  - Expensive, Often used to distribute secret keys

Crypto Building Blocks – cont'd

- Message Digest/Hash function: one-way, collision resistant function that produces a unique fingerprint of input, e.g. MD5, SHA. Typically very fast.
- Keyed Hash: hash function with a secret key as additional input produces Message Authentication Code (MAC). MAC provides source authentication and bulk-data integrity.
- Certificate: signed document attesting subject's ownership of public key, popular format X.509
  - Certificate Authority (CA): verifies claimed identity & proof of possession of private key, issues certificates

SSL Overview



- Client/Server negotiate ciphersuite (Key exchange, MAC, and Symmetric Key algorithm). Eg: RSA_WITH_RC4_128_MD5
- Handshake Protocol uses (expensive) Public Key Crypto Algorithms to establish a shared secret
- Record Layer uses shared secret to perform MAC and (cheaper) Symmetric Key encryption of bulk data

SSL Handshake (RSA)