Workshop:
Android and NFC

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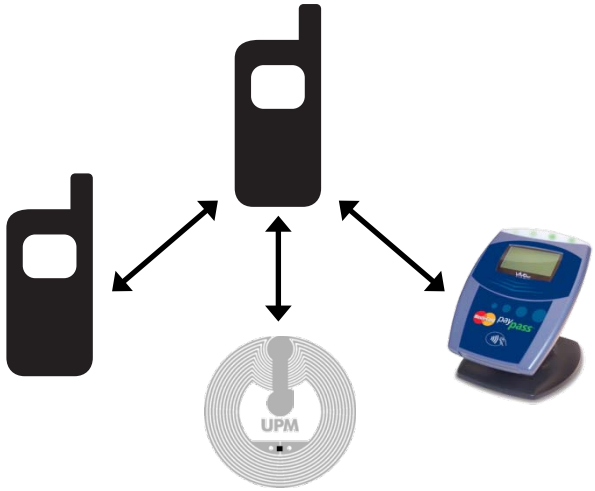
Outline

- Basics
  - NFC
  - Tags
  - NDEF
- Android + NFC
- Hands-On
  - Part 1: NDEF Writer
  - Part 2: NDEF Reader
  - Part 3: Auto-start an app when a tag/NDEF record is detected

Basics: NFC's Operating Modes



- Peer-to-peer mode
  - Communication between two NFC devices
  - Android: Android Beam
- Reader/writer mode
  - NFC devices read & write NFC tags
  - ***Some*** NFC devices read & write other tags and smartcards
  - Android: Support for most NFC-compatible tags and smartcards
- Card emulation mode
  - NFC device imitates a contactless smartcard
  - Intended for security critical applications (payment …)
  - ***Not*** intended for emulation of NFC tags
    → Use peer-to-peer mode instead!
  - Android: No official support

Basics: NFC Tags

- NFC Forum defined 4 standard tag platforms
  - Type 1
    - Innovision Jewel/Topaz
  - Type 2
    - NXP MIFARE Ultralight / Ultralight C
    - NXP NTAG203
    - Infineon my-d move / my-d NFC
  - Type 3
    - Sony FeliCa
  - Type 4
    - NXP MIFARE DESFire
    - Implementable on any contactless smartcard with ISO 7816-4 support (e.g. on any JavaCard)

Basics: NFC Data Exchange Format (NDEF)

- Common format for …
  - storing data on NFC tags
  - transmitting data in peer-to-peer mode
- Data abstraction layer
  - Idea: Applications should work with any NFC tag platform
  - Advantage: Same API for reading and storing data on any NFC tag
    → Users can choose any tag platform (with sufficient storage)!
- Format
  - NDEF record is a data container with data type information
  - NDEF message is a series of one or more NDEF records
  - NFC tag contains NDEF message

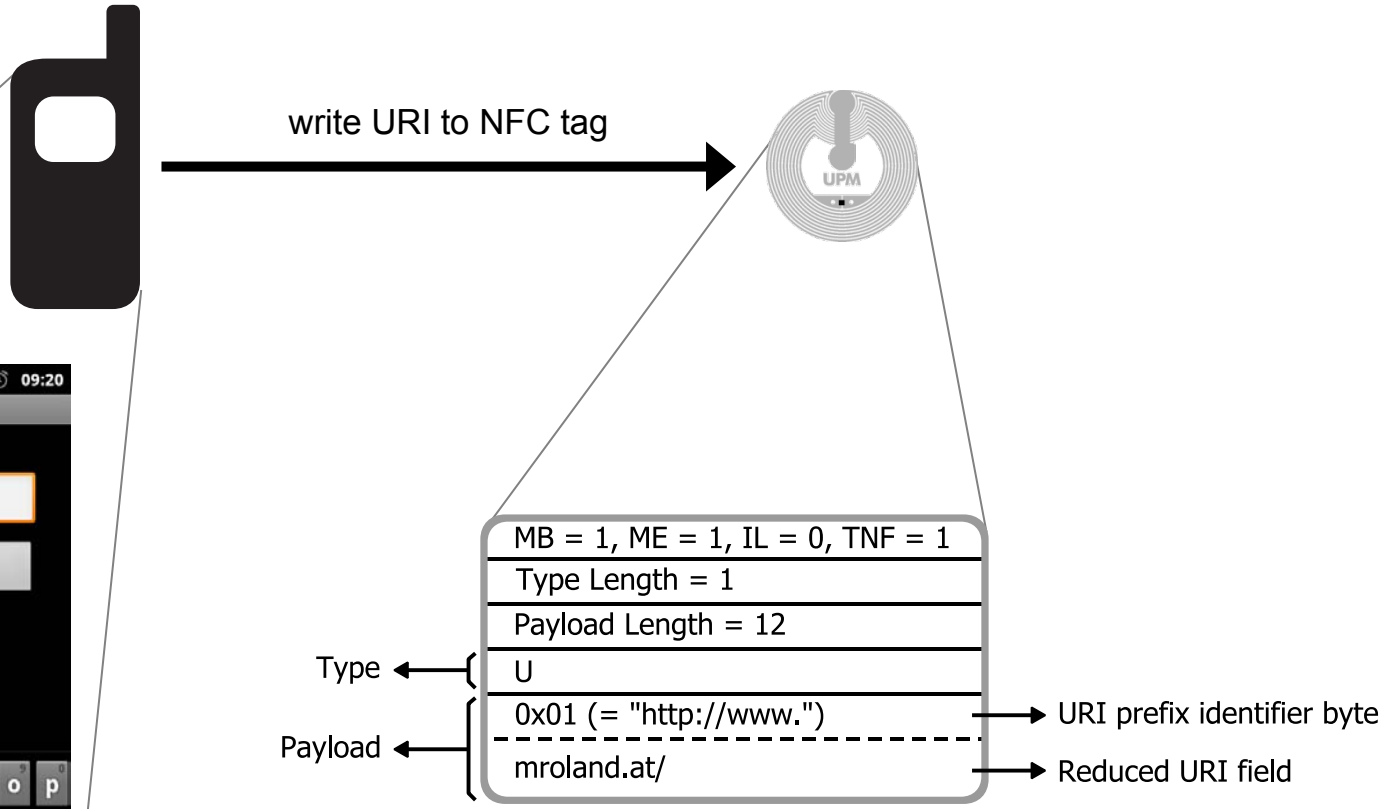
Basics: NDEF Records

- 4 groups of record types
  - NFC Forum Well-known types
    - Defined by the NFC Forum
    - E.g. URI (urn:nfc:wkt:**U**), Text (urn:nfc:wkt:**T**), SmartPoster (urn:nfc:wkt:**Sp**)
  - NFC Forum External types
    - Custom record types definable by application developers
    - E.g. urn:nfc:ext:**mroland.at:example**
  - MIME media types
    - Data formats defined by MIME media types
    - E.g. Business cards (**text/x-vcard**)
  - Absolute URI types
    - Data formats defined by URIs
    - Important: Don’t confuse this with the URI well-known type!

Android's NFC Features

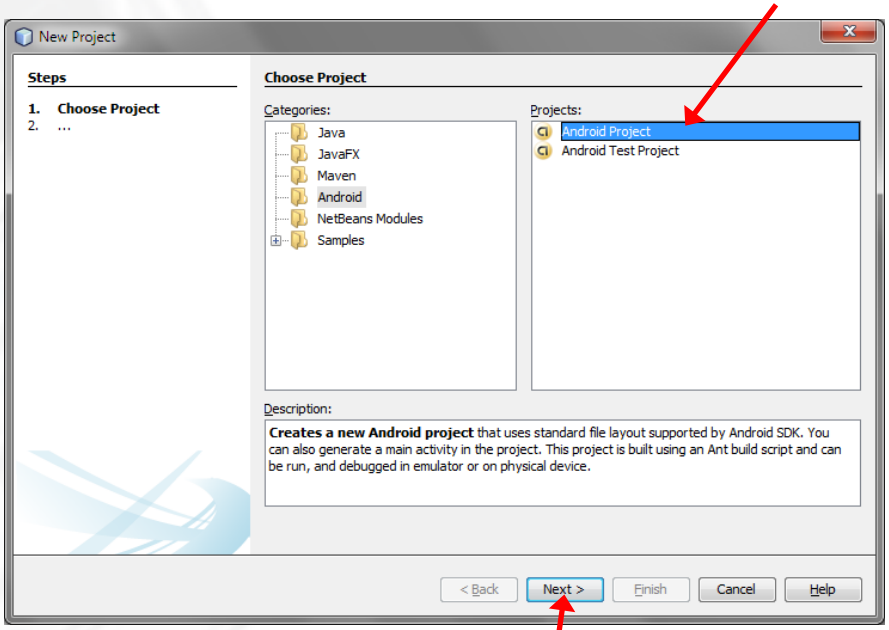
- Peer-to-peer mode
  - Android Beam: Transfer NDEF messages and (large) files
- Reader/writer mode
  - Read and write NDEF data on NFC tags
  - Communication with other tags and smartcards
    - ISO/IEC 14443-A based protocols
    - ISO/IEC 7816-4 APDUs
    - FeliCa (Lite)
    - ISO/IEC 15693 (only if NFC chipset supports it)
    - MIFARE Classic (only if NFC chipset supports it)
  - Auto start apps upon detection of
    - a certain NDEF record
    - a certain tag technology
    - tags not handled by other apps

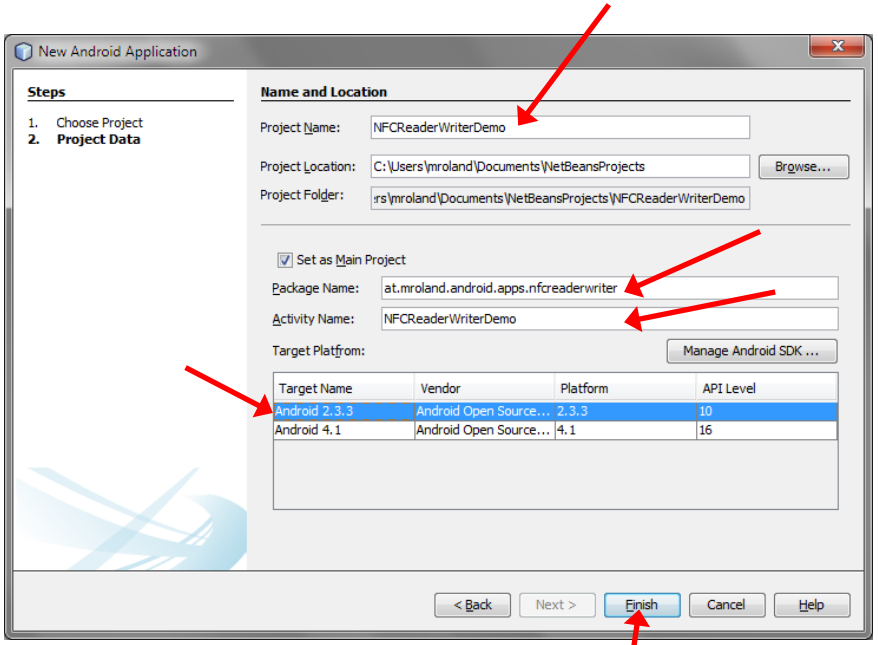
Hands-On (Part 1): NDEF Writer App



Step 1: Create a new Android Project

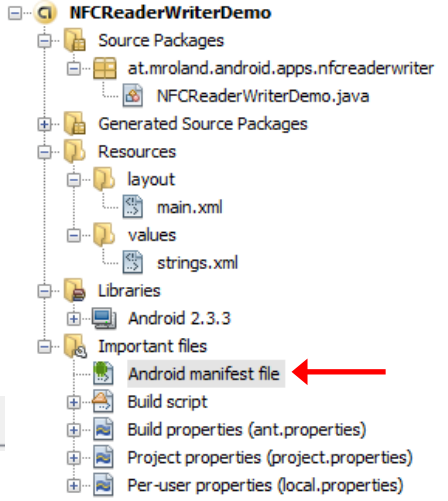
- File → New Project…





Step 2: Android Manifest & NFC

- Require Android 2.3.3 or later
- Request permission to use NFC
- Require devices with NFC hardware



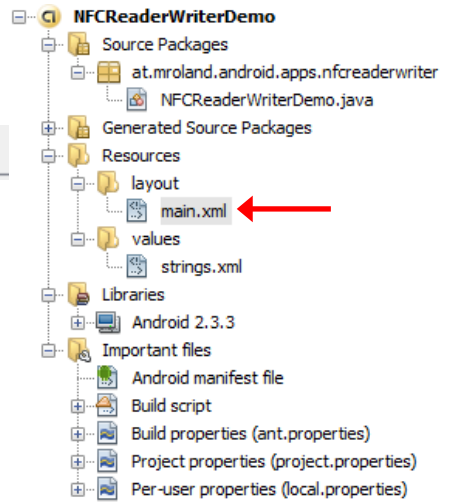
AndroidManifest.xml

```
<manifest ...>
    <!-- Require at least API level 10 (Android 2.3.3+): -->
    <uses-sdk android:minSdkVersion="10"
              android:targetSdkVersion="10" />
    <!-- Request permission to use NFC functionality: -->
    <uses-permission android:name="android.permission.NFC" />
    <!-- Restrict app to devices with NFC hardware: -->
    <uses-feature android:name="android.hardware.nfc"
                  android:required="true" />
    <application android:label="@string/app_name" >
```

Step 3: Add a User Interface

main.xml

```
<?xml version="1.0" encoding="utf-8"?>
<ScrollView xmlns:android="http://schemas.android.com/apk/res/android"
        android:orientation="vertical"
        android:layout_width="match_parent" android:layout_height="match_parent" >
    <LinearLayout android:orientation="vertical"
            android:layout_width="match_parent" android:layout_height="wrap_content" >

        <TextView android:layout_width="match_parent" android:layout_height="wrap_content"
            android:text="URL:"
            android:layout_marginLeft="30dp" android:layout_marginRight="30dp"
            android:layout_marginTop="15dp" android:layout_marginBottom="5dp" />

        <EditText android:id="@+id/myUrl"
            android:layout_width="match_parent" android:layout_height="wrap_content"
            android:text="http://www.mroland.at/"
            android:inputType="textUri"
            android:layout_marginLeft="30dp" android:layout_marginRight="30dp"
            android:layout_marginTop="0dp" android:layout_marginBottom="10dp" />

        <Button android:id="@+id/myWriteUrlButton"
            android:layout_width="match_parent" android:layout_height="wrap_content"
            android:text="Write to NFC Tag..."
            android:layout_marginLeft="30dp" android:layout_marginRight="30dp"
            android:layout_marginTop="0dp" android:layout_marginBottom="15dp"
            android:gravity="center" />

    </LinearLayout>
</ScrollView>
```

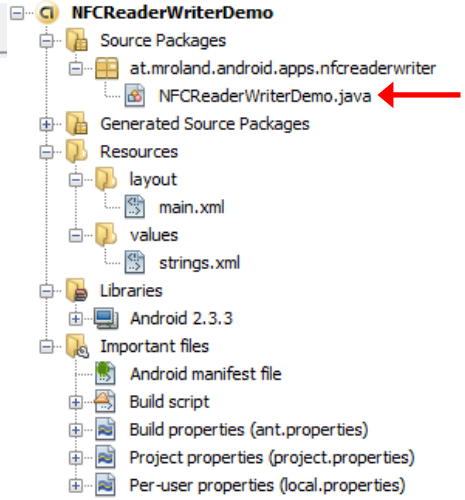


What we've got so far…

Step 4: Creating our Activity

NFCReaderWriterDemo.java

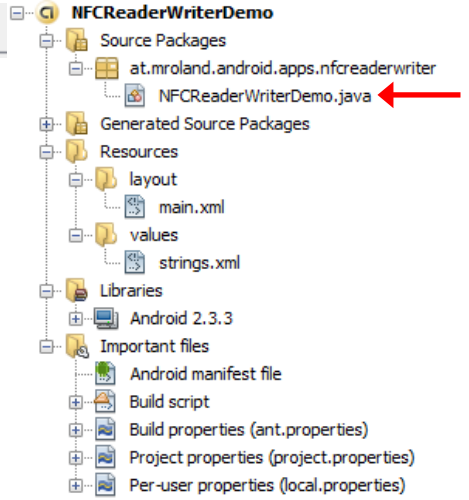
```
private static final int DIALOG_WRITE_URL = 1;
private EditText mMyUrl;
private Button mMyWriteUrlButton;
private boolean mWriteUrl = false;

@Override
public void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.main);

    mMyUrl = (EditText) findViewById(R.id.myUrl);
    mMyWriteUrlButton = (Button) findViewById(R.id.myWriteUrlButton);

    // Set action for "Write URL to tag..." button:
    mMyWriteUrlButton.setOnClickListener(new View.OnClickListener() {
        public void onClick(View v) {
            mWriteUrl = true;
            NFCReaderWriterDemo.this.showDialog(DIALOG_WRITE_URL);
        }
    });
}
```



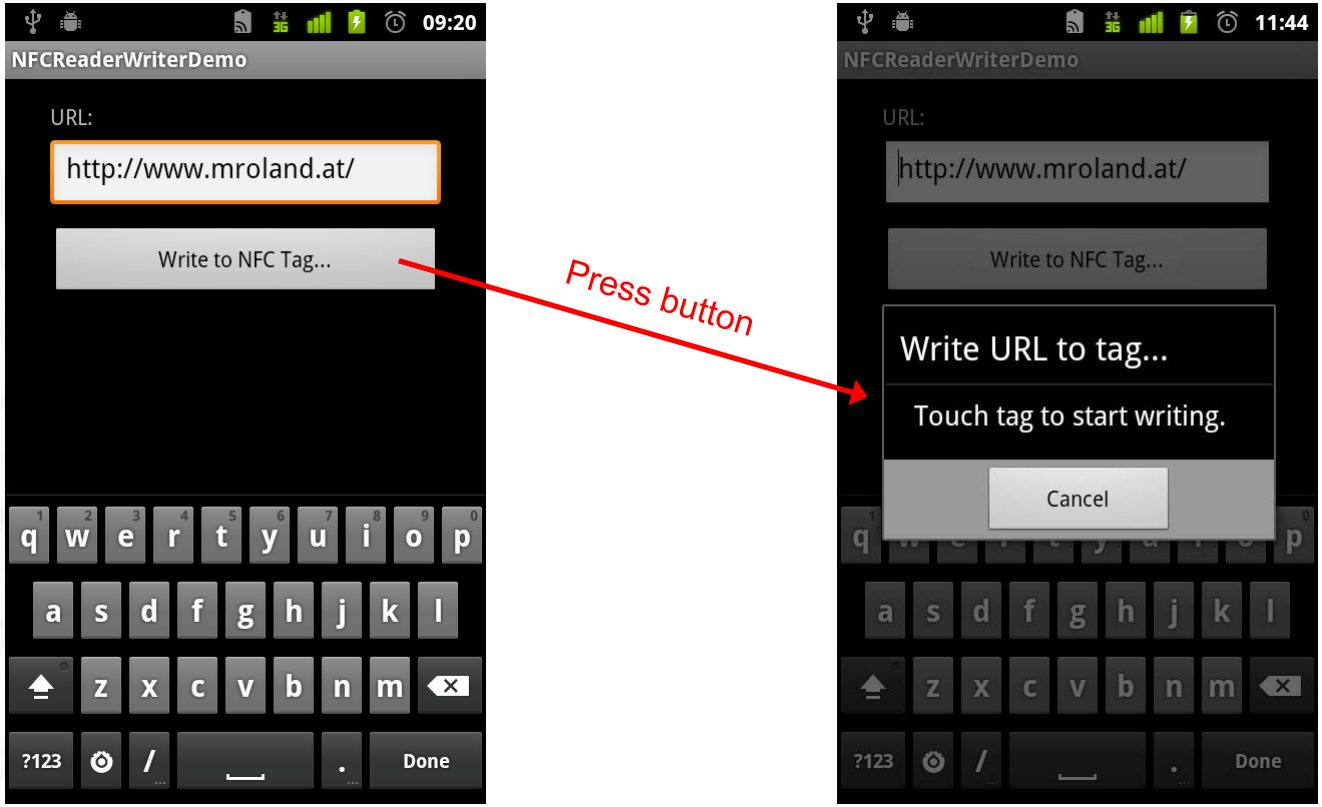
Step 5: A Dialog Box: Ready to Write to Tag

NFCReaderWriterDemo.java

```
@Override
protected Dialog onCreateDialog(int id, Bundle args) {
    switch (id) {
        case DIALOG_WRITE_URL:
            return new AlertDialog.Builder(this)
                    .setTitle("Write URL to tag...")
                    .setMessage("Touch tag to start writing.")
                    .setCancelable(true)
                    .setNeutralButton(android.R.string.cancel,
                                      new DialogInterface.OnClickListener() {
                        public void onClick(DialogInterface d, int arg) {
                            d.cancel();
                        }
                    })
                    .setOnCancelListener(new DialogInterface.OnCancelListener() {
                        public void onCancel(DialogInterface d) {
                            mWriteUrl = false;
                        }
                    }).create();
    }

    return null;
}
```



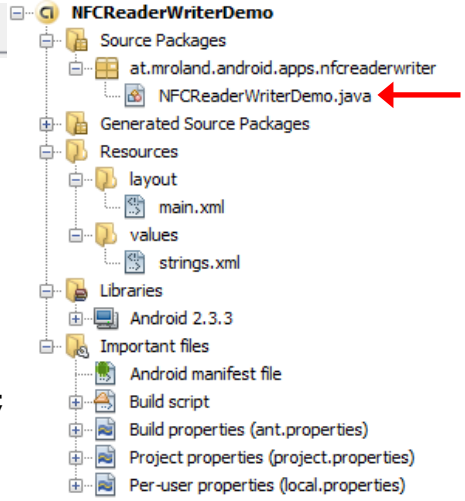
What we've got so far…



Step 6: Foreground Dispatch (Detect Tags)

NFCReaderWriterDemo.java

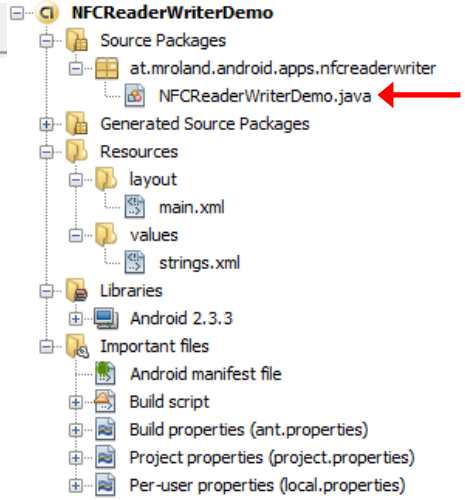
```
private static final int PENDING_INTENT_TECH_DISCOVERED = 1;
private NfcAdapter mNfcAdapter;

@Override
public void onResume() {
    super.onResume();

    // Retrieve an instance of the NfcAdapter:
    NfcManager nfcManager = (NfcManager) this.getSystemService(Context.NFC_SERVICE);
    mNfcAdapter = nfcManager.getDefaultAdapter();

    // Create a PendingIntent to handle discovery of Ndef and NdefFormatable tags:
    PendingIntent pi = createPendingResult(PENDING_INTENT_TECH_DISCOVERED, new Intent(), 0);

    // Enable foreground dispatch for Ndef and NdefFormatable tags:
    mNfcAdapter.enableForegroundDispatch(
            this,
            pi,
            new IntentFilter[]{ new IntentFilter(NfcAdapter.ACTION_TECH_DISCOVERED) },
            new String[][]{
                    new String[]{ "android.nfc.tech.NdefFormatable" },
                    new String[]{ "android.nfc.tech.Ndef" }
            });
}
```



Step 7: Cleanup Foreground Dispatch

NFCReaderWriterDemo.java

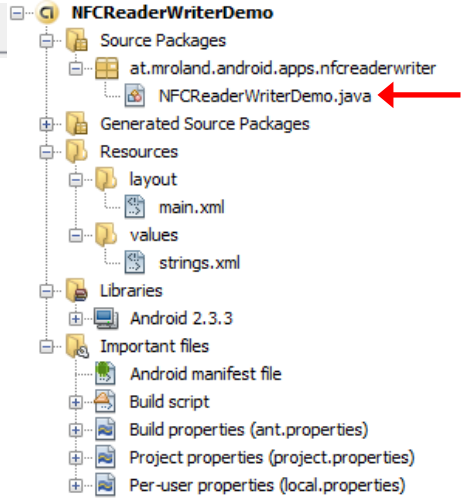
```
@Override
public void onPause() {
    super.onPause();

    // Disable foreground dispatch:
    mNfcAdapter.disableForegroundDispatch(this);
}
```



Step 8: Receive Foreground Dispatch Intent

NFCReaderWriterDemo.java

```
@Override
protected void onActivityResult(int requestCode, int resultCode, Intent data) {
    switch (requestCode) {
        case PENDING_INTENT_TECH_DISCOVERED:
            resolveIntent(data, true);
            break;
    }
}

private void resolveIntent(Intent data, boolean foregroundDispatch) {
    String action = data.getAction();

    if (NfcAdapter.ACTION_TECH_DISCOVERED.equals(action)) {
        Tag tag = data.getParcelableExtra(NfcAdapter.EXTRA_TAG);

        if (foregroundDispatch && mWriteUrl) {
            // This is a foreground dispatch and we want to write our URL
            mWriteUrl = false;

            // TODO: Write the URL to the tag

            dismissDialog(DIALOG_WRITE_URL);
        }
    }
}
```



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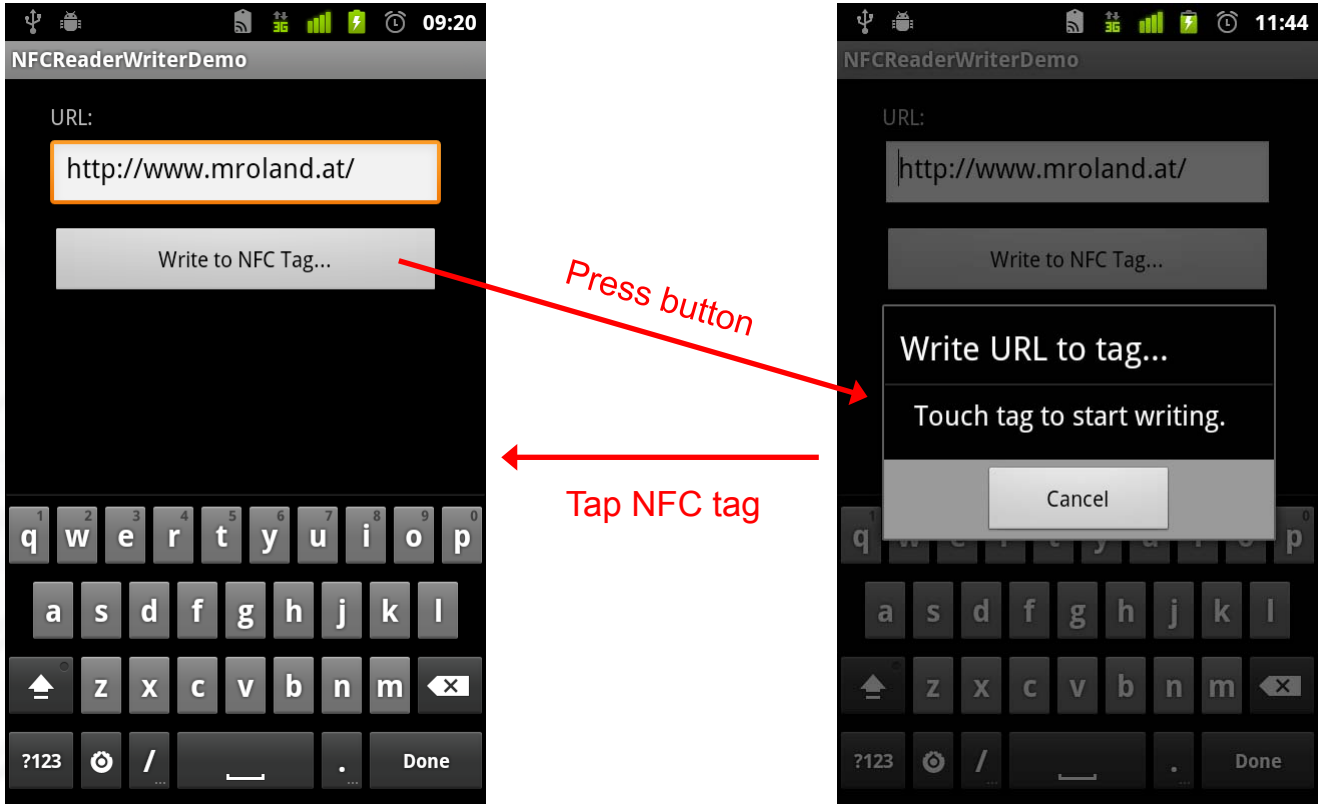
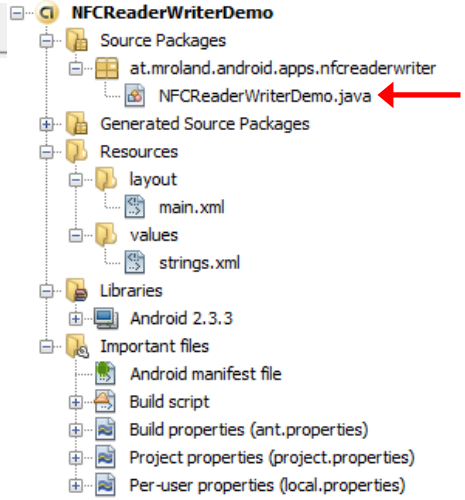


Step 9: Prepare our URI NDEF Message

NFCReaderWriterDemo.java

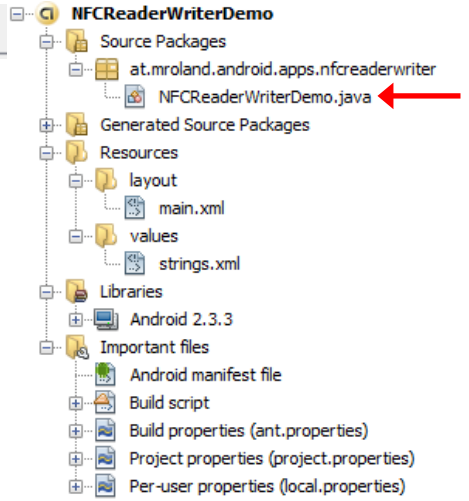
```
if (foregroundDispatch && mWriteUrl) {
    // This is a foreground dispatch and we want to write our URL
    mWriteUrl = false;

    // Get URL from text box:
    String urlStr = mMyUrl.getText().toString();

    // Convert to URL to byte array (UTF-8 encoded):
    byte[] urlBytes = urlStr.getBytes(Charset.forName("UTF-8"));

    // Assemble NDEF URI record payload:
    byte[] urlPayload = new byte[urlBytes.length + 1];
    urlPayload[0] = 0;  // no prefix reduction
    System.arraycopy(urlBytes, 0, urlPayload, 1, urlBytes.length);

    // Create a NDEF URI record (NFC Forum well-known type "urn:nfc:wkt:U")
    NdefRecord urlRecord = new NdefRecord(NdefRecord.TNF_WELL_KNOWN, /* TNF: NFC Forum well-known type */
                                          NdefRecord.RTD_URI,        /* Type: urn:nfc:wkt:U */
                                          new byte[0],               /* no ID */
                                          urlPayload);

    // Create NDEF message from URI record:
    NdefMessage msg = new NdefMessage(new NdefRecord[]{urlRecord});

    // TODO: Write the NDEF message to the tag
```



Step 10: Write NDEF to Preformatted Tag

NFCReaderWriterDemo.java

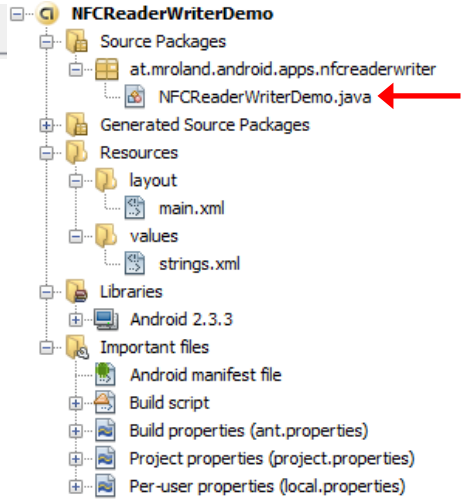
```
Tag tag = data.getParcelableExtra(NfcAdapter.EXTRA_TAG);
[...]
    // Create NDEF message from URI record:
    NdefMessage msg = new NdefMessage(new NdefRecord[]{urlRecord});

    Ndef ndefTag = Ndef.get(tag);
    if (ndefTag != null) {
        // Our tag is already formatted, we just need to write our message

        try {
            // Connect to tag:
            ndefTag.connect();

            // Write NDEF message:
            ndefTag.writeNdefMessage(msg);
        } catch (Exception e) {
        } finally {
            // Close connection:
            try { ndefTag.close(); } catch (Exception e) { }
        }
    } else {
        // Our tag is not NDEF formatted!
    }

    dismissDialog(DIALOG_WRITE_URL);
```



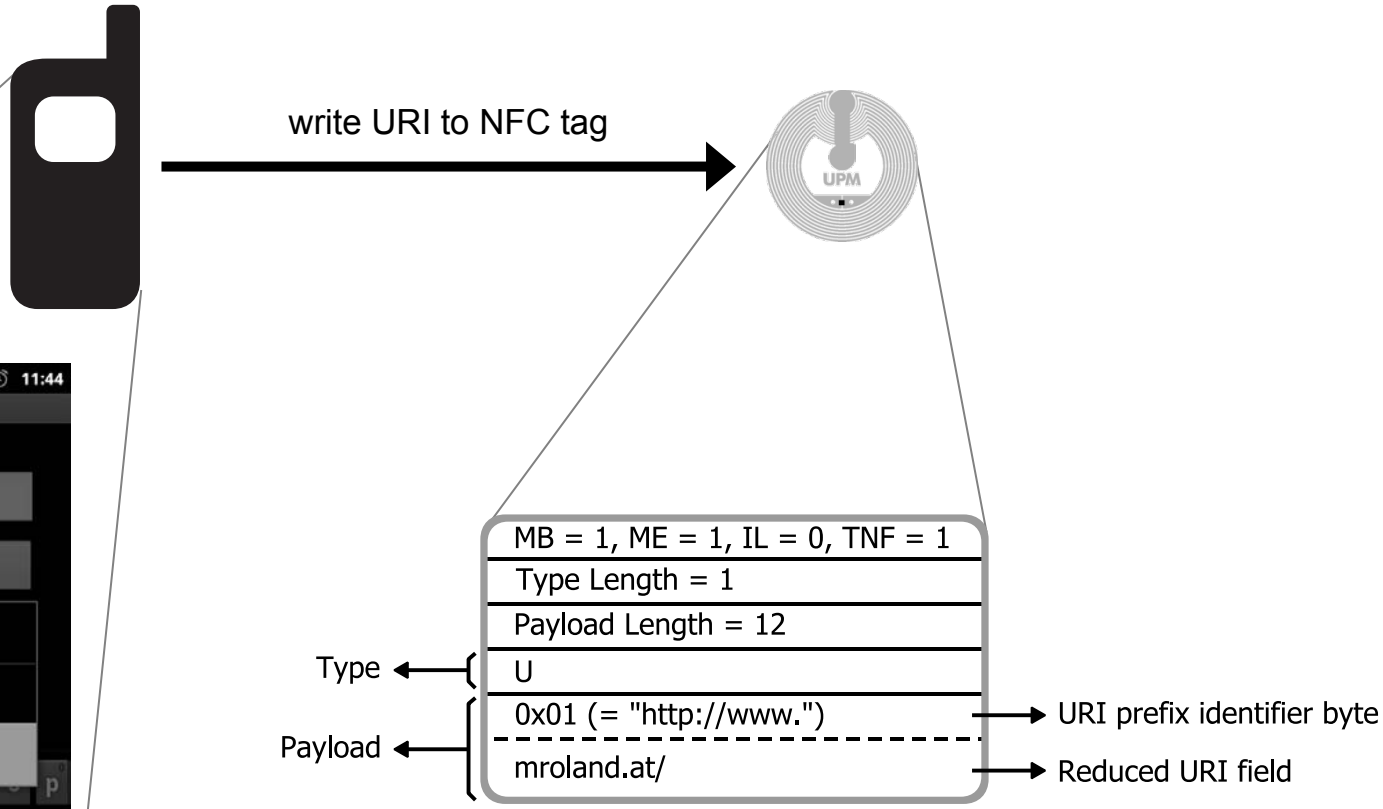
Step 11: Write NDEF to Unformatted Tag

NFCReaderWriterDemo.java

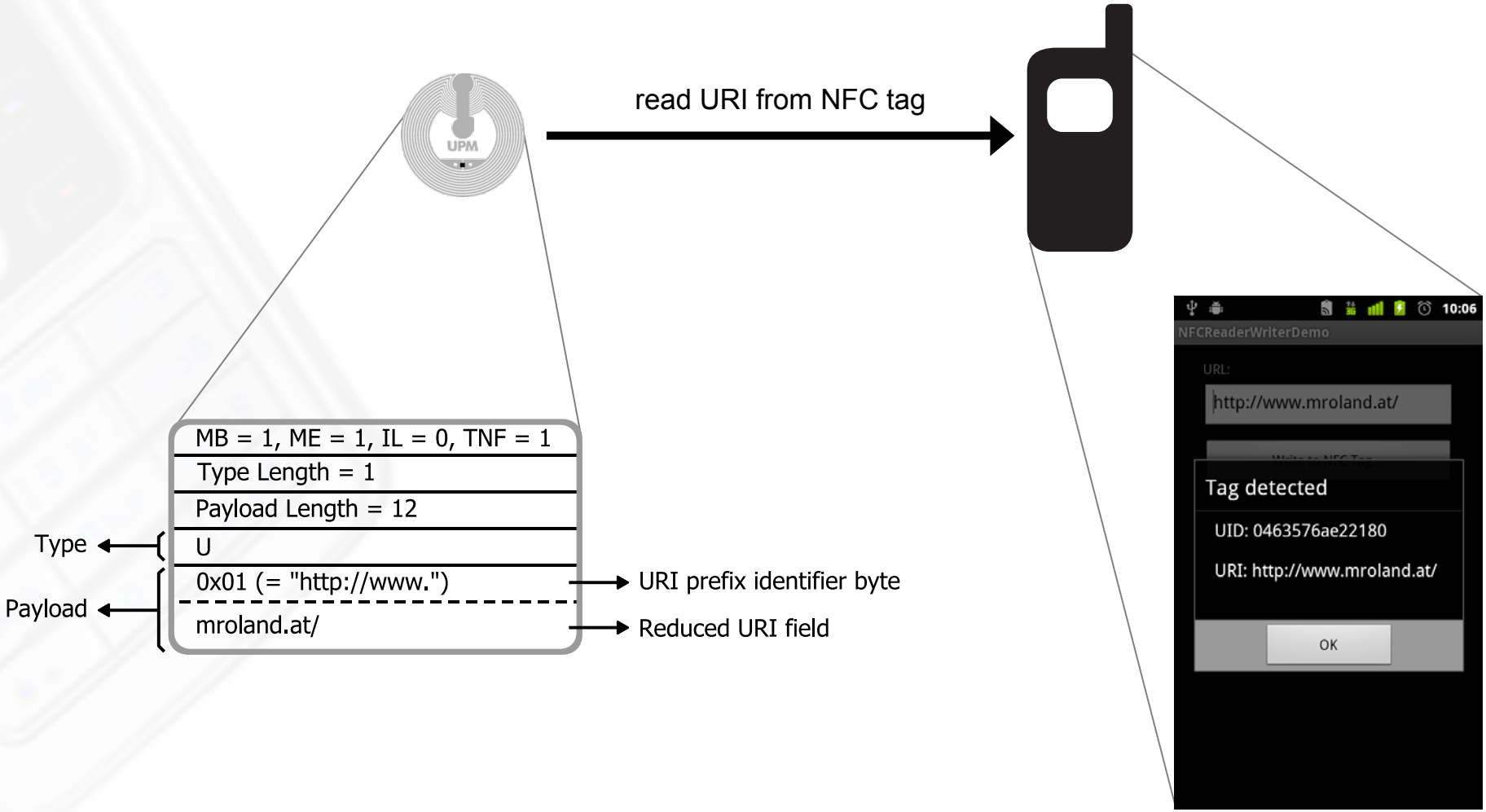
```
if (ndefTag != null) {
    [...]
} else {
    // Our tag is not NDEF formatted!
    NdefFormatable ndefFormatableTag = NdefFormatable.get(tag);
    if (ndefFormatableTag != null) {
        // Our tag is not yet formatted, we need to format it with our message

        try {
            // Connect to tag:
            ndefFormatableTag.connect();

            // Format with NDEF message:
            ndefFormatableTag.format(msg);
        } catch (Exception e) {
        } finally {
            // Close connection:
            try { ndefFormatableTag.close(); } catch (Exception e) { }
        }
    }
}

dismissDialog(DIALOG_WRITE_URL);
```



What we've got so far: NDEF Writer App



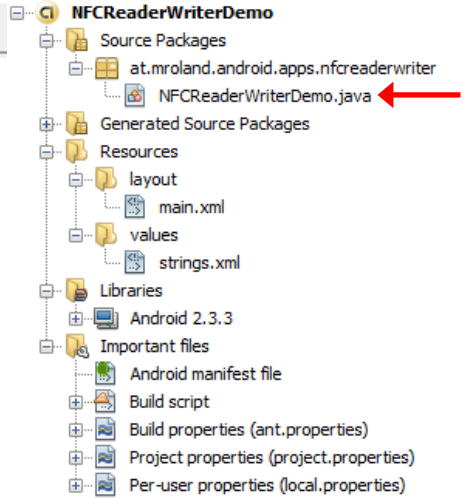
Hands-On (Part 2): NDEF Reader App



Step 1: A Simple Dialog Box: Detected a Tag

NFCReaderWriterDemo.java

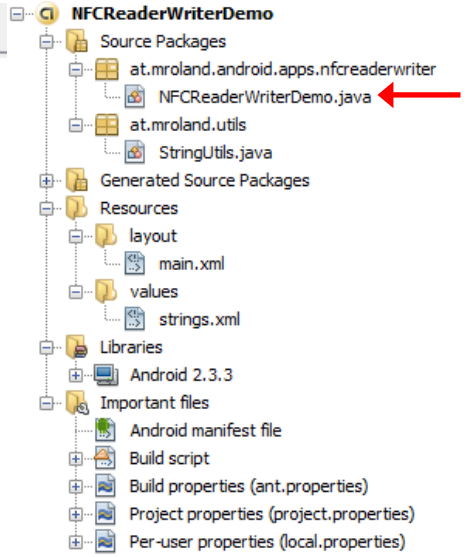
```
private static final int DIALOG_NEW_TAG = 3;
private static final String ARG_MESSAGE = "message";

protected Dialog onCreateDialog(int id, Bundle args) {
        [...]
        case DIALOG_NEW_TAG:
            return new AlertDialog.Builder(this)
                    .setTitle("Tag detected")
                    .setCancelable(true)
                    .setNeutralButton(android.R.string.ok,
                                      new DialogInterface.OnClickListener() {
                        public void onClick(DialogInterface d, int arg) {
                            d.dismiss();
                        }
                    }).create();

@Override
protected void onPrepareDialog(int id, Dialog dialog, Bundle args) {
    switch (id) {
        case DIALOG_NEW_TAG:
            String message = args.getString(ARG_MESSAGE);
            if (message != null) ((AlertDialog) dialog).setMessage(message);
            break;
    }
}
```



Step 2: Detect the Tag

NFCReaderWriterDemo.java

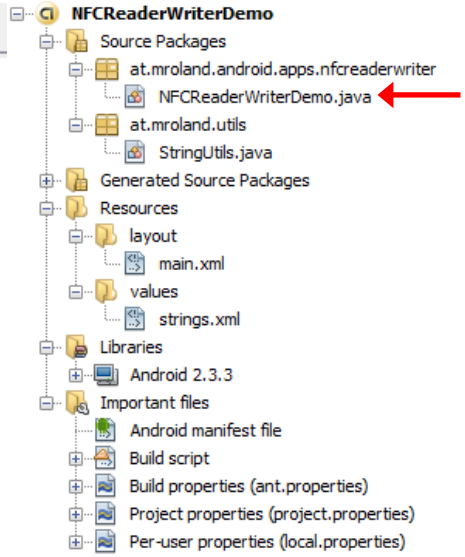
```
private void resolveIntent(Intent data, boolean foregroundDispatch) {
    String action = data.getAction();

    if (NfcAdapter.ACTION_TECH_DISCOVERED.equals(action)) {
        Tag tag = data.getParcelableExtra(NfcAdapter.EXTRA_TAG);

        if (foregroundDispatch && mWriteUrl) {
            [...]
        } else {
            // Let's read the tag whenever we are not in write mode

            // Retrieve information from tag and display it
            StringBuilder tagInfo = new StringBuilder();

            // Get tag's UID:
            byte[] uid = tag.getId();
            tagInfo.append("UID: ")
                   .append(StringUtils.convertByteArrayToHexString(uid))
                   .append("\n\n");

            // TODO: Read NDEF messages
        }
    }
}
```



Step 3: Read NDEF Message from Tag

NFCReaderWriterDemo.java

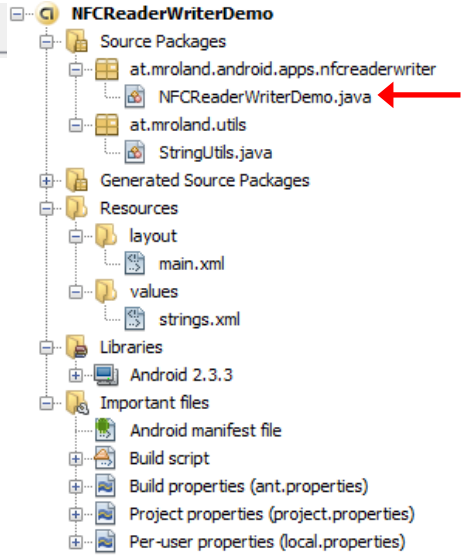
```
private void resolveIntent(Intent data, boolean foregroundDispatch) {
        [...]
        // Get tag's NDEF messages:
        Parcelable[] ndefRaw =
                data.getParcelableArrayExtra(NfcAdapter.EXTRA_NDEF_MESSAGES);
        NdefMessage[] ndefMsgs = null;
        if (ndefRaw != null) {
            ndefMsgs = new NdefMessage[ndefRaw.length];
            for (int i = 0; i < ndefMsgs.length; ++i) {
                ndefMsgs[i] = (NdefMessage) ndefRaw[i];
            }
        }

        // TODO: Find our URI record
```



Step 4: Find URI Record in NDEF Messages

NFCReaderWriterDemo.java

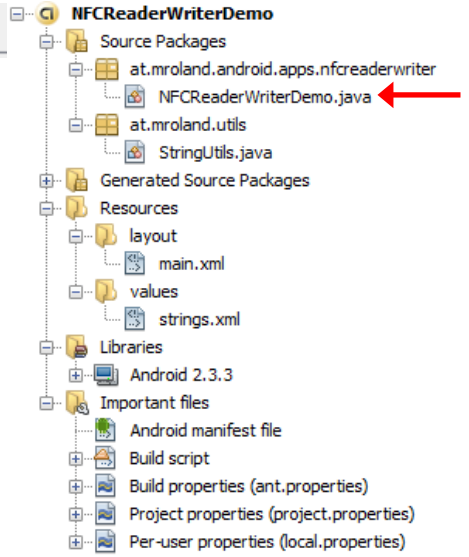
```
private void resolveIntent(Intent data, boolean foregroundDispatch) {
        [...]
        if (ndefMsgs != null) {
            // Iterate through all NDEF messages on the tag:
            for (int i = 0; i < ndefMsgs.length; ++i) {
                // Get NDEF message's records:
                NdefRecord[] records = ndefMsgs[i].getRecords();

                if (records != null) {
                    // Iterate through all NDEF records:
                    for (int j = 0; j < records.length; ++j) {
                        // Test if this record is a URI record:
                        if ((records[j].getTnf() == NdefRecord.TNF_WELL_KNOWN)
                                && Arrays.equals(records[j].getType(), NdefRecord.RTD_URI)) {
                            byte[] payload = records[j].getPayload();
                            // Drop prefix identifier byte and convert remaining URL to string (UTF-8):
                            String uri = new String(Arrays.copyOfRange(payload, 1, payload.length),
                                                    Charset.forName("UTF-8"));
                            tagInfo.append("URI: ").append(uri).append("\n");
                        }
                    }
                }
            }
        }
```



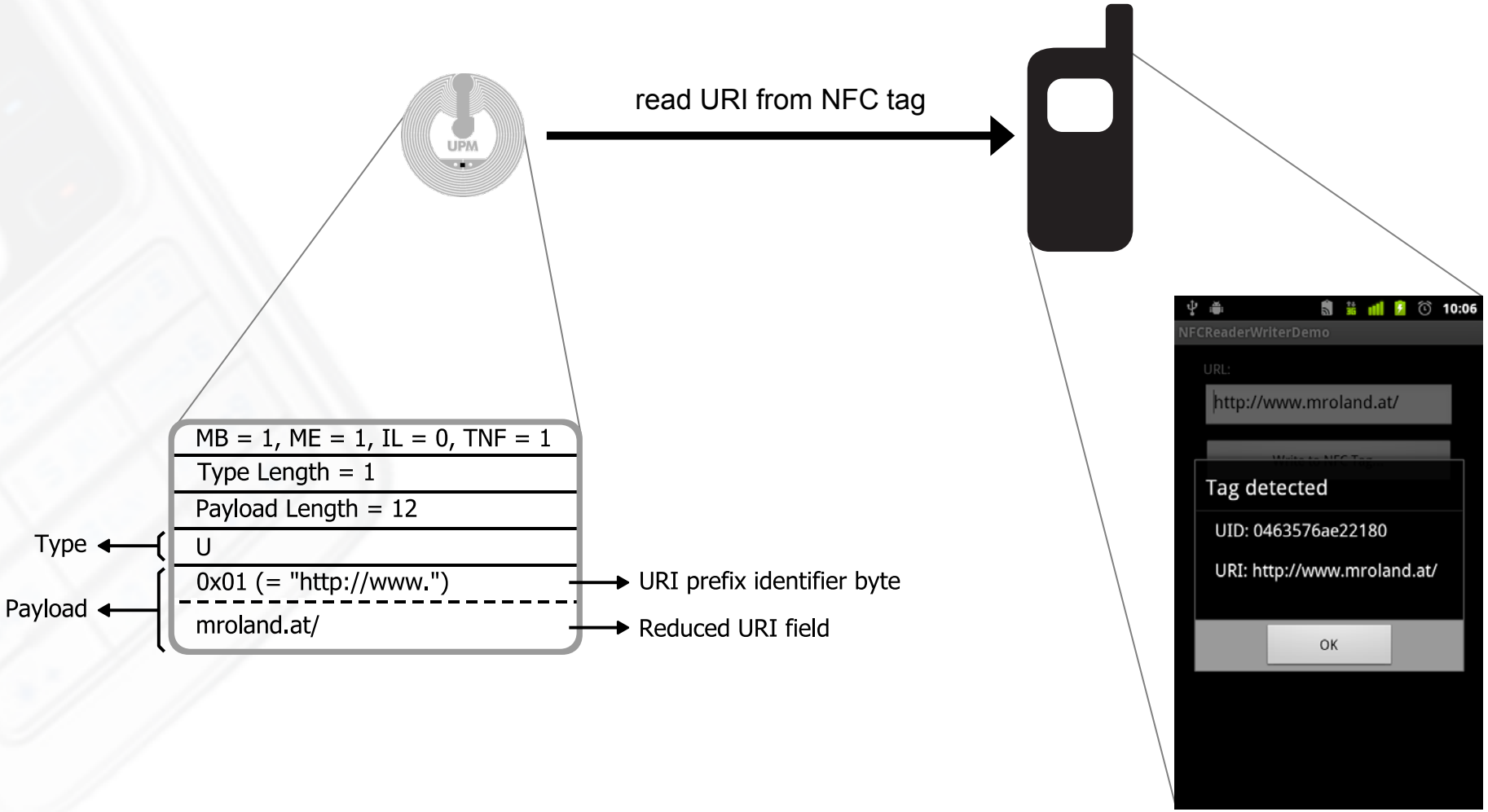
Step 5: Display Tag Data in a Dialog Box

NFCReaderWriterDemo.java

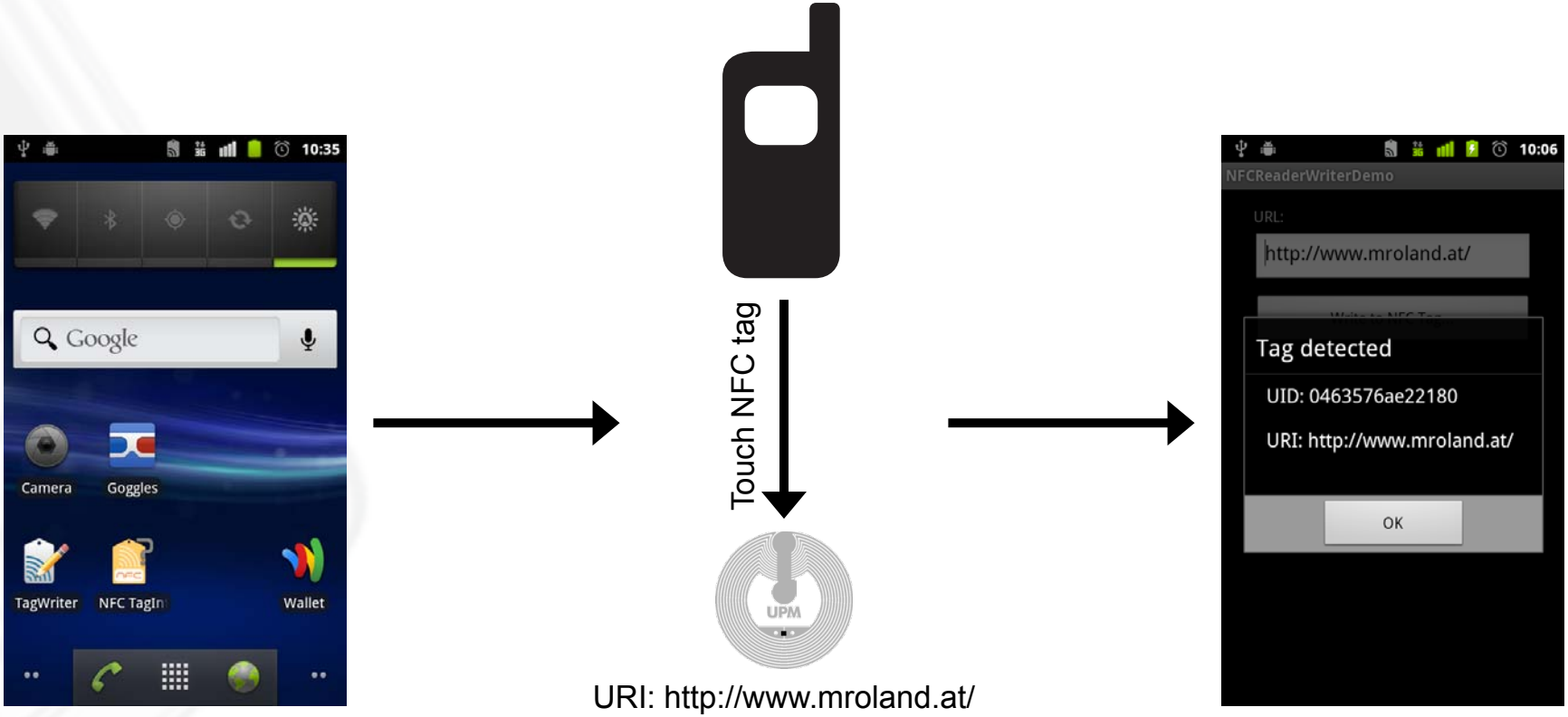
```
private void resolveIntent(Intent data, boolean foregroundDispatch) {
        [...]
        if (ndefMsgs != null) {
            [...]
        }

        Bundle args = new Bundle();
        args.putString(ARG_MESSAGE, tagInfo.toString());
        showDialog(DIALOG_NEW_TAG, args);
```



What we've got so far: NDEF Reader App



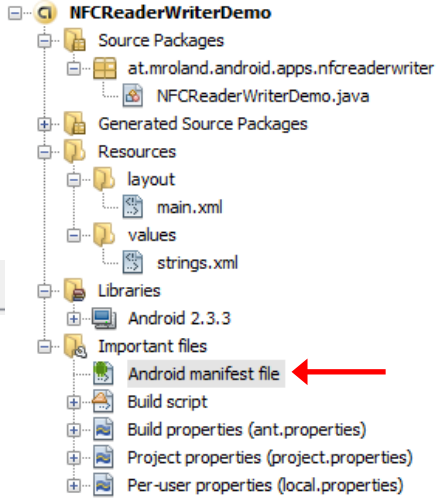
Hands-On (Part 3): Auto-start App for our URI



URI: http://www.mroland.at/

Step 1: Android Manifest & Auto-start on NFC Tag

- Launch Mode: *singleTask*
- Handling configuration changes
- Intent filter: NDEF_DISCOVERED



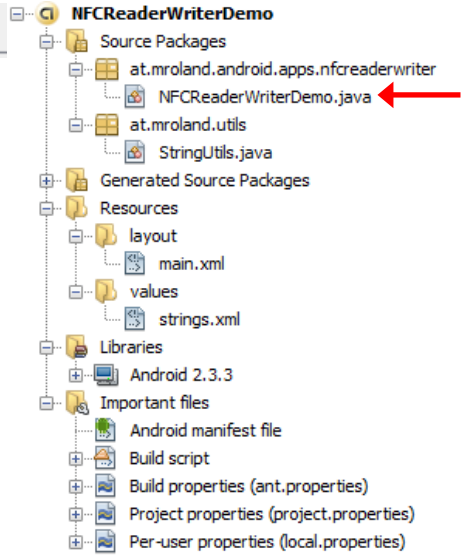
AndroidManifest.xml

```
<activity android:name="NFCReaderWriterDemo"
          android:label="@string/app_name"
          android:launchMode="singleTask"
          android:configChanges="orientation|keyboardHidden" >
    <!-- Make our app startable through the app launcher: -->
    <intent-filter>
        <action android:name="android.intent.action.MAIN" />
        <category android:name="android.intent.category.LAUNCHER" />
    </intent-filter>
    <!-- Make our app startable through our URL: -->
    <intent-filter>
        <action android:name="android.nfc.action.NDEF_DISCOVERED" />
        <category android:name="android.intent.category.DEFAULT" />
        <data android:scheme="http"
              android:host="www.mroland.at"
              android:pathPrefix="" />
    </intent-filter>
</activity>
```

Step 2: Handle NDEF_DISCOVERED Intent

NFCReaderWriterDemo.java

```
@Override
public void onCreate(Bundle savedInstanceState) {
        [...]
    // Resolve the intent that started us:
    resolveIntent(this.getIntent(), false);
}

@Override
public void onNewIntent(Intent data) {
    resolveIntent(data, false);
}

private void resolveIntent(Intent data, boolean foregroundDispatch) {
    String action = data.getAction();

    // We were started from the recent applications history: just show our main activity
    if ((data.getFlags() & Intent.FLAG_ACTIVITY_LAUNCHED_FROM_HISTORY) != 0) return;

    if (NfcAdapter.ACTION_TECH_DISCOVERED.equals(action)
            || NfcAdapter.ACTION_NDEF_DISCOVERED.equals(action)) {
        Tag tag = data.getParcelableExtra(NfcAdapter.EXTRA_TAG);

        if (foregroundDispatch && mWriteUrl) {
```



Downloads

- Full example code:

  https://www.mroland.at/uploads/2012/09/NFCCongress2012_NFCReaderWriterDemo_full.zip

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