EMV Transactions with the ID TECH Universal SDK

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Introduction

EMV transaction processing is significantly more complex than magstripe transaction processing. More steps are involved, and there is considerable two-way back-and-forth communication between terminal and reader. Understanding all of the security, data packaging, messaging, and other considerations that apply to EMV transactions can be daunting.

ID TECH's Level 2 EMV kernel takes care of many of the low-level details involved in carrying out EMV transactions. The developer's job is made even easier by ID TECH's Universal SDK, which provides high-level-language access to library routines that can greatly speed EMV development. The Universal SDK (available for iOS, Android, and Windows) gives developers a rich API and a robust set of tools (and source-code examples) for communicating with ID TECH's EMV-capable card readers, greatly facilitating the creation, testing, and debugging of EMV applications using languages like C#, Java, Swift, or Objective-C.

> **NOTE:** To obtain the Universal SDK, please visit the Downloads page at https://atlassian.idtechproducts.com/confluence/display/KB/Downloads+-+Home. On that page, you will find links to special builds of the SDK for each supported ID TECH product and platform. (You'll also find user manuals and a variety of other helpful supporting documents.) No registration is necessary. All downloads are free and unlocked.

ID TECH's Universal SDK comes with source code for rich, fully featured demo apps, showing how the ID TECH EMV Level 2 kernel can be leveraged to create secure, high-performance applications with minimal effort. Nevertheless, knowing "where to begin" can be a challenge. So with that in mind, this document will look at some of the more important aspects of handling EMV transactions, and how the Universal SDK can help.

Section 1 of this document (How Does an "EMV Transaction" Work?) gives a quick semi-technical overview of what happens in an "EMV transaction." Most of the low-level interactions discussed in that section happen automatically, in ID TECH devices, at the kernel level; we present the information merely for background. If you have not already familiarized yourself with how EMV transactions work, take time to understand this section.

Section 2 of this document (EMV Transactions Using the Universal SDK) talks about EMV process flow in the context of a custom application that communicates with an ID TECH device. In that section, we'll have frequent opportunity to talk about Universal SDK libraries (and associated methods) and what *you* have to do to get an EMV transaction to work.

1 How Does an "EMV Transaction" Work?

This section assumes that the device in question is carrying out a *contact* EMV transaction. If you're familiar with EMV 4.3 specifications, this will be a quick review of things you probably already know. If you haven't studied the EMV specifications, you should do so. What follows is not a substitute for reading the actual specs.

The best way to think of an EMV transaction is as a conversation between an ICC (chip) card and a terminal, with the card reader acting as an intermediary. *Most* of the back-and-forth communication that occurs during an EMV transaction actually occurs between the card and the reader's Level 2 kernel. The terminal (i.e., the host device to which the card reader is connected) is notified of the outcome of various stages of the conversation. Depending on the types of notifications received, the terminal might need to display certain messages on a display device, prompt the cardholder for more information, or (in some cases) do nothing. Most of the kernel-level operations that happen require no action on the terminal's part. For more information on what the terminal's responsibilities are at various points in the transaction, see the section on EMV Transaction Flow.

In the meantime, let's look at what goes on during an EMV transaction.

At a high level, the EMV transaction can be broken down into the following phases:

- ICC Power Up (ATR)
- Application Selection
- Data Authentication
- Processing Restrictions
- Version Check
- Application Usage Control
- Date Checks
- Cardholder Verification
- Terminal Risk Management
- Floor Limit Checking
- Velocity Checking
- Terminal Action Analysis
- Card Action Analysis
- Issuer Script Processing
- Completion

Internally, the reader maintains two checklists. One is called the “Terminal Verification Results” or TVR. And the other one is called the “Transaction Status Information” or TSI. Both checklists start as arrays of bits set to 0 (two bytes' worth for TSI, five bytes for TVR).

During the conversation between the card and the terminal, the reader will check off certain items on its TVR checklist in to make sure it doesn’t do something unwarranted, like accept a fraudulent payment. At the same time, the reader will check off items on its TSI checklist to keep track of where the transaction is in the process.

At the end of a transaction, the TSI and TVR data are returned in TLV tags 9B and 95, respectively.

1.1 ICC Power Up (ATR)

The card reader will begin a transaction by asking the card if it's there, essentially, resulting in an Answer to Reset (ATR). The Answer To Reset (ATR) is a message output by a Smart Card conforming to ISO/IEC 7816 standards, following electrical reset of the card's chip by a card reader. The presence of an ATR is often used as an indication that a Smart Card is operative, and its content can be examined as a first test that the card is of the appropriate kind for a given usage.

If the card responds appropriately to the ATR, a communication session will be set up between the card and the reader, using either the T0 protocol or the T1 protocol, as defined in ISO/IEC 7816-3.

1.2 Application Selection

An EMV card may be configured for multiple payment applications. During the first step, after the card is powered up, an application is selected. The process for doing this is somewhat involved, since the card reader maintains its *own* list of pre-loaded applications (which may be added to or in some cases reconfigured by the terminal application). The selection process involves the reader querying the card to discover which applications are available on the card. Eventually, through a well-determined procedure specified by EMVCo, the card and reader "decide" on an application to use.

> **Note:** At runtime, application selection occurs at the kernel level. You normally will not have to write your own code for this.

Once an application is selected, the card will respond with a Processing-options Data Object List (PDOL). The PDOL is a list of data elements that the card needs to receive from the terminal in order to execute the next command in the transaction process. In essence, the terminal (or card reader, in this case) needs to know what EMV functionality the card supports, and where the information is (on the chip) to support that functionality. To obtain the necessary information, the reader queries the card via APDUs conforming to ISO-7816. This is a very low-level type of interaction that you will ordinarily not have to concern yourself with (since the kernel handles it automatically); however, if you should need to interact with a card at this level, the ID TECH Universal SDK does expose APDU-related methods that enable this kind of interaction.

1.3 Data Authentication

In the previous step, the reader will have obtained an Application Interchange Profile (AIP) indicating the types of functions supported by the card. The AIP tells which type of Offline Data Authentication the card supports.

There are three types of ODA:

- Combined Dynamic Data Authentication (CDA)
- Dynamic Data Authentication (DDA)
- Static Data Authentication (SDA)

Industry (EMV) specifications spell out the procedure for determining which kind of ODA must be used under a given set of conditions. The details aren't important here, since (again) this is a low-level operation that happens at the kernel level.

Depending on the outcome of ODA processing, various bits will be set in the TVR and TSI.

1.4 Processing Restrictions

Sometimes a card will be restricted for use in a specific country, or for a specific service; or a card may be expired.

During the “processing restrictions” step the terminal checks to see:

- Whether the application version on the card is the same as on the terminal
- Whether the type of transaction is allowed
- Whether the card is valid and not expired

Again, these are kernel checks; they do not require that you write any code yourself.

1.5 Version Check

The card and the reader (if it's certified by a card issuer) both have an application version number for a given application. This number is prescribed by the payment scheme (for example, MasterCard). As set forth by EMV specifications, the reader checks the applicable application version numbers to see if they agree. Depending on the outcome of this step, a bit in the TVR will be set.

1.6 Application Usage Control

In the application selection process, the reader will have received an Application Usage Control (AUC) record. This 2-byte bit array will tell the reader whether the card:

Is valid for domestic cash transaction
Is valid for international cash transaction
Is valid for domestic goods
Is valid for international goods
Is valid for domestic services
Is valid for international services
Is valid at ATMs
Is valid at terminals other than ATMs
Allows domestic cashback
Allows international cashback

The reader checks whether the transaction it is processing is allowed by the AUC or not. (This is a kernel check. You do not have to write code for it.) If the transaction is *not* allowed, the ‘Requested service not allowed for card product’ bit in the TVR is set to 1.

1.7 Date Checks

Often, a card will be issued that is not yet valid at the moment of issuing. This information can be set on the card in the Application Effective Date record.

If the card has an Application Effective Date and it is after the current date, the ‘Application not yet effective’ bit in the TVR is set. Otherwise nothing is set.

Applications have an expiration date. The card exposes the Application Expiration Date to the reader. If this date is in the *future*, the transaction continues normally. Otherwise the ‘Expired Application’ bit in the TVR is set to 1.

1.8 Cardholder Verification

The card issuer specifies various ways in which a cardholder may be allowed to prove that he or she is the rightful holder of the card. These methods of proof are called Cardholder Verification Methods (or CVMs).

The CVMs allowed by EMV can (at the issuer's option) include:

- Online PIN
- Offline Enciphered PIN
- Offline Plaintext PIN
- Signature
- No-CVM

The process for determining how a particular CVM is selected and how it works is somewhat involved. (See the EMV specifications for details.) The most important thing to note is that *some* type of CVM is generally performed (except for certain low-transaction-amount scenarios, in which "No-CVM" might apply), and the results of the CVM processing will set appropriate bits in the TVR and TSI. For example, the TVR contains bits that can record:

- Cardholder verification was not successful
- Unrecognized CVM
- PIN Try Limit exceeded
- PIN entry required and PIN pad not present or not working
- PIN entry required, PIN pad present, but PIN was not entered
- Online PIN entered

Once the “cardholder verification” step has been run, the “Cardholder verification was performed” bit in the TSI will be set to 1.

1.9 Terminal Risk Management

Obviously, the objective of terminal risk management is to protect the payment system from fraud. The risk of fraud is generally smaller when the terminal requests online approval from the issuer for a transaction. But online approval is not always *required*.

To determine whether the transaction should go online, the terminal will check three things:

- If the transaction is above the offline floor limit
- Whether it wants to randomly select this transaction to go online
- Whether the card has had, or not had, an online authorization in a while

Once this step has been performed the ‘Terminal risk management was performed’ bit in the TSI is set to 1.

1.10 Floor Limit Checking

If the value of the transaction is above the floor limit set in the terminal, the “Transaction exceeds floor limit” bit in the TVR is set to 1.

Note that a terminal may randomly select a transaction for online processing. If the transaction is selected, the ‘Transaction selected randomly for online processing’ bit in the TVR will be set to 1.

1.11 Velocity Checking

If a card has not been online in a while, it may be that the current usage attempt is fraudulent. To mitigate the attendant risk, a card may have a Lower Consecutive Offline Limit (LCOL) and a Upper Consecutive Offline Limit (UCOL) set.

If the LCOL and UCOL have been provided to the payment device, it must do *velocity checking*.

The device will first request the Application Transaction Counter (ATC) and the Last Online ATC Register. The ATC is a counter that is incremented by one every time a transaction is performed. The Last Online ATC Register is set to the value of the ATC when a transaction has been online. The difference between the two is the number of transactions that have been performed offline.

- If the difference is higher than the LCOL, the ‘Lower consecutive limit exceeded’ bit in the TVR is set to 1
- If the difference is also higher than the UCOL, the ‘Upper consecutive limit exceeded’ bit in the TVR is also set to 1

- If the Last Online ATC Register is 0, the “New card” bit in the TVR will be set to 1

1.12 Terminal Action Analysis

The payment device must decide whether to decline the transaction, complete it offline, or complete it online. At this point, it is only a preliminary decision. The device has to *ask the card* for confirmation of its decision. The card may change the decision during the “card action analysis” step (below).

Both the payment device and the card have settings that determine the action to take based on the TVR.

The settings on the card are called Issuer Action Codes (IAC). The settings on the device are called Terminal Action Codes (TAC).

There are three IACs and three TACs:

- TAC/IAC Denial
- TAC/IAC Online
- TAC/IAC Default

Just as with the TVR, these action codes are 5-byte bit arrays. These arrays are logically OR'd together at runtime (and compared with the TVR) to determine a course of action. The details aren't important here, since this is handled in the kernel in accordance with EMV requirements.

Regardless of the decision taken by the device, it has to request confirmation from the card. (The card may disagree with the terminal.) The payment device requests confirmation by using the Generate Application Cryptogram (or "Generate AC") command. With this command, it will request to either: *decline, approve offline*, or *approve online*.

Along with this request, the terminal will provide the card with the required data for the Card Action Analysis step (see below). When the terminal asks the card to perform the Card Action Analysis, this is called the Generate Application Cryptogram request, or "first Gen AC."

> **Comment:** *In most EMV transactions, there are two Gen AC requests. This means the card is asked for advice twice: once before going online, and once after the online decision has been obtained.*

1.13 Card Action Analysis

In this step, the card will perform its own risk management checks. *How* the card does this is outside the scope of EMV. The card only needs to communicate the results of its decision. This result is communicated using a *cryptogram*, which is a cryptographic hash of transaction-related data. The issuer will use the cryptogram and the data in it to confirm that the card is authentic and that the proper risk management has been performed.

The card will generate one of three possible cryptograms:

- Transaction approved: Transaction Certificate (TC)
- Request online approval: Authorization Request Cryptogram (ARQC)
- Transaction declined: Application Authentication Cryptogram (AAC)

At the conclusion of this step, the card provides a TC, ARQC, or AAC cryptogram to the payment device (in Tag 9F26) together with the transaction data that were used to generate the cryptogram. The terminal will set the "Card risk management was performed" bit in the TSI to 1.

If the card generates a TC, the transaction is approved offline, but the terminal needs to provide the cryptogram to the Issuer in order to capture the funds of the transaction. If the card gives an ARQC, the terminal will need to request authorization online. (This is the expected outcome in many scenarios, particularly in the U.S., which is essentially an online-only or at least predominantly online payment environment.) If the terminal received a TC or AAC, the transaction is now finished (with an offline approval or offline decline, respectively).

1.13.1 Online Processing & Issuer Authentication

After the first Gen AC request, the card may provide an ARQC, indicating that the terminal or payment app should go online for authorization. This step is the responsibility of the payment app, rather than the card reader. It usually means contacting a gateway, acquirer, or other network endpoint where the request can be relayed to an Issuer or other authority. The decision of the Issuer is then relayed back to the gateway and originating app.

The processing done by the Issuer during this step is technically outside the scope of EMV, but at the very least, the issuer will attempt to authenticate the card by validating the ARQC cryptogram. In addition, the issuer will generally perform its own risk management and check if the cardholder has sufficient credit or funds.

The Issuer will respond with either an approval or decline code. The issuer will also generate a response cryptogram using data known to the card. The card can use this data to verify that the response received is really from the issuer.

The card will already have told the payment device whether or not it supports issuer authentication (this information is given in the AIP). If a response cryptogram was received and the card *supports* issuer authentication, the terminal will request authentication using the EXTERNAL AUTHENTICATE command. If the resulting issuer authentication fails, the "Issuer authentication failed" bit in the TVR will be set to 1.

Once issuer authentication has been performed, the "Issuer authentication was performed" bit in the TSI is set to 1.

What Happens If the Terminal Cannot Go Online?

In case of power outage, network outage, etc., it may not be possible to go online. In most cases, the transaction can still continue. In fact, in some cases it is permissible for the terminal app itself to approve the transaction unilaterally, pending later approval by the Issuer. This is known as Stand-In Processing (STIP). Every acquirer has its own rules for performing STIP. You should obtain, understand, and adhere to the STIP rules laid out in your acquirer's implementation guide (or integrator's guide). Please consult that guide for details.

1.14 Issuer Script Processing

In some instances, the Issuer may need to update data on the card. This can be done using issuer script processing.

> **Comment:** *Depending on whether scripts were specified in Tag 71 or 72, script processing may occur before (71) or after (72) the second Gen AC request.*

If issuer scripts were processed, the card reader will set the “Script processing was performed” bit in the TSI to 1. Also:

- If issuer script processing *fails* before the second Generate AC command, the “Script processing failed before final GENERATE AC” bit in TVR will be set to 1.
- If the issuer script processing fails *after* the second generate AC command, the “Script processing failed after final GENERATE AC” bit in TVR will be set to 1.

1.15 Completion

If the terminal went online for approval and a response was received, the terminal will request a final transaction cryptogram using the Generate AC command for a second time. (This is the so-called "second Gen AC.") As before, the cryptogram itself will come in tag 9F26, and information about the *type* of cryptogram will come in tag 9F27.

At completion time, the card can only respond with a TC or AAC. The TC is required in order to capture the funds from the issuer. AAC is typically associated with a Decline. (Note that in EMV, the card can disagree with the online advice and issue an AAC even if the online authority approved the transaction.) The card will typically issue an AAC if the terminal provided a 'Z3' response code in Tag 8A (indicating "unable to go online").

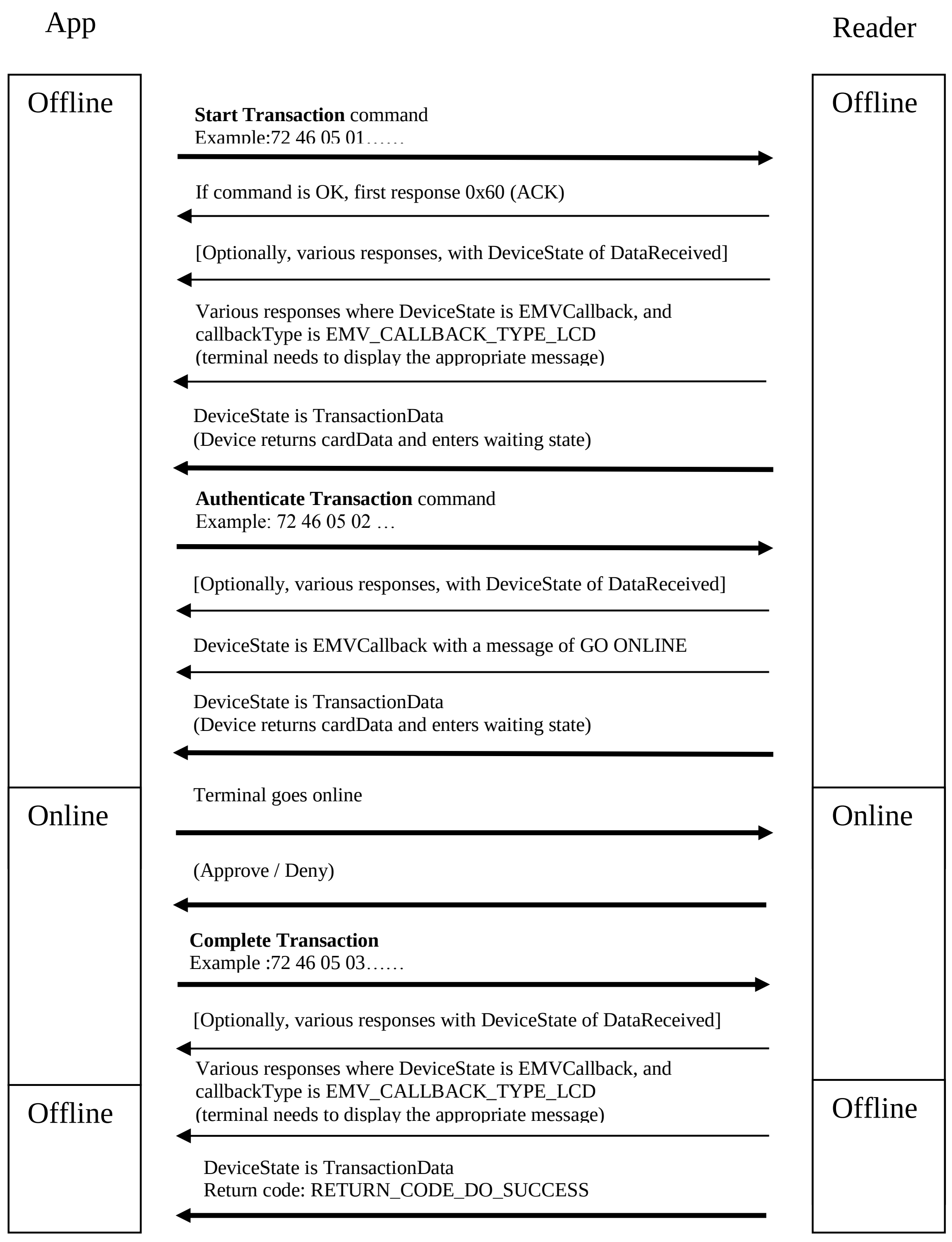
Note that the card's advice is not necessarily binding, for purposes of completing a transaction. That is to say, a final cryptogram result of AAC doesn't mean the transaction cannot subsequently be posted for settlement. In Faster EMV or Quick Chip, for example, an AAC is *always* returned (since the card is routinely told the terminal could not go online; and the card is bound to issue an AAC after the 'Z3'). An AAC at this point in the transaction is merely advisory: It's the card's *advice*. The issuer can overrule it.

2 EMV Transactions using the Universal SDK

For the integrator writing applications for ID TECH devices using the Universal SDK, the good news is that almost all of the operations described above are *kernel-level* operations that happen automatically, requiring no custom code. Extra code might come into play if you need to customize various aspects of the steps outlined above or configure the device in a certain way. To help with this, the ID TECH Universal SDK exposes a variety of methods for obtaining low-level access to features of the kernel that are normally "out of sight" (such as AIDs and CAPKs), so that you can override or update various features as needed.

> **Note:** ID TECH's Universal SDK comes with source code for two apps. One of the apps represents the project created using the Tutorial in the documentation. (It contains "Simple_Demo" in the file name.) The other demo app is more elaborate (and contains "SDKDemo" in the name). In the sections below, references to the "demo app" apply to the latter project, not the Tutorial project.

At a high level, conducting an EMV transaction on an ID TECH device results in a flow that looks like this (see diagram below):


App
Reader
Offline
Offline
Start Transaction command
Example:72 46 05 01……
If command is OK, first response 0x60 (ACK)
[Optionally, various responses, with DeviceState of DataReceived]
Various responses where DeviceState is EMVCallback, and callbackType is EMV_CALLBACK_TYPE_LCD (terminal needs to display the appropriate message)
DeviceState is TransactionData (Device returns cardData and enters waiting state)
Authenticate Transaction command
Example: 72 46 05 02 …
[Optionally, various responses, with DeviceState of DataReceived]
DeviceState is EMVCallback with a message of GO ONLINE
DeviceState is TransactionData (Device returns cardData and enters waiting state)
Online
Online
Terminal goes online
(Approve / Deny)
Complete Transaction
Example :72 46 05 03……
[Optionally, various responses with DeviceState of DataReceived]
Various responses where DeviceState is EMVCallback, and callbackType is EMV_CALLBACK_TYPE_LCD (terminal needs to display the appropriate message)
Offline
Offline
DeviceState is TransactionData
Return code: RETURN_CODE_DO_SUCCESS

The above diagram shows a typical transaction. From the developer's point of view, the transaction is really a three-part process, involving calls to asynchronous SDK methods `emv_startTransaction(), emv_authenticateTransaction()`, and `emv_completeTransaction()`. During each phase, the reader carries out various operations at the kernel level, then calls the application back via the callback registered using `IDT_Device.setCallback(MessageCallBack)`. Messages received from the reader can be inspected to determine what the terminal needs to do during each phase (such as process exceptions, display messages on a screen, or go online).

In order to perform EMV transactions using the Universal SDK, you will first need to initialize your card reader (e.g., Augusta) via the methods outlined below; then you can run transactions using the appropriate transaction methods, namely `emv_startTransaction()`, `emv_authenticateTransaction()`, and `emv_completeTransaction()`. Let's take a look, first, at the initializations you'll need to do.

2.1 Configuration

Before attempting to perform any EMV transactions using the Universal SDK, you will want to be sure your card reader is properly configured. At a minimum, this means setting:

- Terminal Configuration values
- Default AIDs
- CAPKs

If you bypass these steps, you will encounter errors when trying to do an EMV transaction.

The Universal Demo program (for Windows) contains built-in commands, and a graphical UI, to assist you in performing these setup steps. However, the SDK also allows you to do configuration tasks programmatically. In the sections that follow, we talk about programmatic configuration using the C# version of the Universal SDK.

2.1.1 Terminal Configuration

Prior to performing EMV transactions, you will need to set certain terminal configuration parameters that will apply to all transactions, using `SharedController.emv_setTerminalData()`.

To accomplish this one-time configuration operation, you might have a private method called `mySetTerminalData()` that looks something like this:

```
private void mySetTerminalData(object sender, EventArgs e)
{
        byte[] term = Common.getByteArray("
        5f3601029f1a0208409f3501229f330360f8c89f4005f00000a0019f1e085465726d6
        96e616c9f150212349f160f3030303030303030303030303030309f1c0838373635343332319f4e2231303732
        312057616c6b65722053742e20437970726573732c204341202c5553412edf260101df1008656e667265737a6
        8df110101df270100dfee150101dfee160100dfee170107dfee180180dfee1e08f0dc3cf0c29e9400dfee1f01
        80dfee1b083030303135313030dfee20013cdfee21010adfee2203323c3c");

        RETURN_CODE rt = IDT_MiniSmartII.SharedController.emv_setTerminalData(term);

        if (rt == RETURN_CODE.RETURN_CODE_DO_SUCCESS) {
                tbOutput.AppendText("Set Terminal Successful:" + " nrnn");
        }
        else {
                log("Save Terminal failed Error Code: " + "0x" + String.Format("{0:X}",
                (ushort)rt) + ": " + IDTechSDK.errorCode.getErrorString(rt) + "nrnn");
        }
}
```

Here, the byte array `term` contains TLV information for "Transaction Currency Exponent" (tag 5F36), "Terminal Country Code" (tag 9F1A), "Terminal Type" (tag 9F35), "Terminal Capabilities" (tag 9F33), "Additional Terminal Capabilities (tag 9F40), "Interface Device Serial Number" (9F1E), "Tag Application Label" (tag 50), "Directory Discretionary Template" (tag 73), and "Issuer Script Command" (tag 86).

> **Comment:** *The terminal configuration step (see code above) is typically a one-time setup operation. It does not need to be done on a per-transaction basis.*

ID TECH readers can support at least five major kernel configurations (1C through 5C). The choice of configuration is guided by, among other things, the type of Cardholder Verification Method supported by the scenario:

- Configuration 1C is for attended devices using chip and PIN (e.g. ID TECH VP8800).
- Augusta supports 2C (which allows cardholder confirmation of Language Selection and application selection) and 5C (no customer confirmations). For Quick Chip, use 5C.
- The default configuration for Spectrum Pro is 4C, which supports "no CVM" (only).
- 3C adds chip and PIN capabilities with the use of a PIN pad (e.g., ID TECH SmartPIN L100). Neither 3C nor 4C allow for chip-and-signature. (Chip-and-signature wouldn't make sense for Spectrum Pro, which is an unattended device.)

Many terminal capability settings (which are configured by means of TLVs, as indicated above) are considered "minor" settings that can be tailored at will to a given scenario. Some are considered "major" settings that can't be changed without producing a runtime error. For more information on Terminal Settings and kernel configurations (and the settings that can be changed without producing an error), be sure to consult the Knowledge Base article at the following URL: https://atlassian.idtechproducts.com/confluence/pages/viewpage.action?pageId=32276534.

2.1.2 Setting AIDs

The card reader needs to know which application identifiers (AIDs) you intend to support. This is something you will configure using code similar to the following:

```
        RETURN_CODE rt;
         byte[] name = Common.getByteArray("a0000000031010");
         byte[] aid = 
Common.getByteArray("9f01065649534130305f5701005f2a0208409f090200965f3601029f1b040000
3a98df25039f3704df28039f0802dfee150101df13050000000000df14050000000000df1505000000000
0df180100df170400002710df190100");

        // Tell Augusta the name and value of the AID you wish to support:
         rt = IDT_Augusta.SharedController.emv_setApplicationData(name, aid);

         if (rt == RETURN_CODE.RETURN_CODE_DO_SUCCESS)
              {
                  tbOutput.AppendText("Default AID Successful\r\n");
              }
         else
              {
                  tbOutput.AppendText("Default AID failed Error Code: " +
                "0x" + String.Format("{0:X}", (ushort)rt) +
                ":" + IDTechSDK.errorCode.getErrorString(rt) +
                "\r\n");
        }
```

Consult the Universal SDK's demo app source code for more detail. (The demo app source code shows how to load AIDs for all the commonly supported card applications.)

As with Terminal Configuration, setting the default AIDs is something you will likely do only once, not on a per-transaction basis.

2.1.3 Setting CAPKs

You will also want to set the reader's supported Certificate Authority Public Key values. The code for doing this looks like:

```
      byte[] capk = 
Common.getByteArray("a000000003500101b769775668cacb5d22a647d1d993141edab7237b00010001
8000d11197590057b84196c2f4d11a8f3c05408f422a35d702f90106ea5b019bb28ae607aa9cdebcd0d81
a38d48c7ebb0062d287369ec0c42124246ac30d80cd602ab7238d51084ded4698162c59d25eac1e66255b
4db2352526ef0982c3b8ad3d1cce85b01db5788e75e09f44be7361366def9d1e1317b05e5d0ff5290f88a
0db47");
       RETURN_CODE rt = IDT_Augusta.SharedController.emv_setCAPK(capk);
```

This (again) is something you will likely configure once, not on a per-transaction basis.

With initializations out of the way, it's time to do an EMV transaction. Let's look at the phases of the EMV transaction, one by one.

2.2 Start Transaction

This command, issued via the method `emv_startTransaction()`, does the following:

When a card is already seated:

- Initiates a Power On sequence with the ICC reader
- If an ICC cannot be detected (no ATR:Answer To Reset), then a fallback condition occurs and a swipe is requested.
- If ATR received, establishes timeout for receipt of “Authenticate Transaction” command and transmits “Application Data” parameters to the card, and the EMV transaction starts.

When a card is not seated:

- The MSR Swipe is enabled, along with monitoring for a card to be inserted.

When a Swipe is executed first:

- If a non-ICC card is swiped, the swipe data is returned and the transaction is over.

- If a ICC card is swiped, the swipe is rejected and the kernel prompts to use the ICC (insert the card).

Note that if you wish to inspect ATR response parameters, you may optionally issue an ICC power-on via `SharedController.icc_powerOnICC(ref ATR)` *before* calling `emv_startTransaction()`, although this is strictly optional.

When executing `emv_startTransaction()`, TLV data should, at a minimum, contain the following tags:

- 9F02: Amount
- 9F03: Other amount
- 9C: Transaction type

In addition, you can (optionally) include a DFEE1A tag to request what tags be included in the final response callback. The DFEE1A tag is a proprietary ID TECH tag that wrappers other tags. For example, to request that tags 9F36, 9F37, and 95 be included in the output from the Authenticate Transaction stage, specify DFEE1A059F369F3795 as part of the TLV byte array. (The 05 after DFEE1A is the total length of the included tags, 9F36, 9F37, and 95.) Please be aware that this will override the default set of default tags returned. (See the discussion under Obtaining Extra Tags, further below.)

Another tag that can be used is DFEF1F, which causes the Authenticate Transaction phase to be entered automatically (without a call to `emv_authenticateTransaction()`, after Start Transaction has finished. To use this tag, supply two bytes of data: a first byte (with 1 to signal auto-authenticate, or 0 to signal no auto-authenticate) and a second byte that, if set to a value of 1, will force the transaction to go online. (Zero is the default.) The complete TLV might look something like DFEF1F020100, where 02 is the length.

After the Start Transaction command is issued, the reader will interact with the card to determine the correct AID to use, and carry out other low-level EMV operations. It will call the application back a minimum of two times (once with ACK, and once with TransactionData), but there will typically be additional status callbacks as well. You can inspect the `DeviceState` object (the second argument to the callback) to determine whether the reader is responding with device data, an EMV callback, or transaction data. (Code for this is shown in the sample demo app that comes with the Universal SDK.)

With a typical ID TECH EMV L2 device (e.g., Augusta), the first response from the reader, in raw form, might look like 02010006060603, which is just an ACK (0x06) wrapped in a header and trailer. The header in this case is STX (0x02) plus two length bytes, whereas the trailer consists of an LRC value, checksum, and ETX (0x03). Since the message is just ACK (0x06), the LRC is 0x06 and the checksum is 0x06.

When the reader calls back with an `EMVCallback`, you should check the callback type, and if it is `EMV_CALLBACK_TYPE_LCD`, have the terminal display the appropriate message on the device LCD or POS screen. (Code showing how to do this is given in the sample demo app.) If action is required from the customer before proceeding, the payment app should prompt the customer as necessary (using the terminal UI) and collect any needed info before proceeding. See the demo app's `processEMVCallback()` method for an example of how to handle `EMVCallback` messages.

When the reader responds with a `DeviceState` of `TransactionData` and an EMV result of `EMV_RESULT_CODE_AUTHENTICATE_TRANSACTION`, the transaction can go to the next step. At this stage, the reader will respond only to three commands: “Authenticate EMV L2 Transaction” , “Cancel EMV L2 Transaction”, or “Retrieve EMV L2 Transaction Data,” or (in other words) the SDK methods `emv_authenticateTransaction()`, `emv_cancelTransaction()`, and `emv_retrieveTransactionResult()`. The reader will block, at this point, while your app decides which method to call. (Eventually, it will time out, if no action is taken.) You can use this opportunity to inspect the available transaction data to determine whether to invoke any extra logic that might be appropriate to the transaction. (For example, this might be when the app decides that the customer is eligible for a loyalty discount.) If no special logic applies, simply proceed to the next step: Authenticate Transaction.

2.3 Authenticate Transaction

In this stage of the transaction, the card reader's EMV kernel will attempt to apply cardholder verification methods, terminal risk management logic, and any other logic required under EMV processing rules, in order to determine whether the terminal needs to go online for authorization.

The purpose of this stage is to allow the return of card tags so that you can (optionally) modify/change any existing tags. For example, a common use of this stage is to evaluate the Primary Account Number to determine if it is a loyalty card, and if so, provide a discount by changing the previously submitted amount (Tag 9F02) to a lesser amount. Any changed tags can be passed as a TLV stream in this method's parameter list.

In most scenarios, this step of pausing the EMV transaction to evaluate collected card data is not needed or utilized. This step can be bypassed by passing tag DFEF1F with a value of 0100 (or 0101 if force-online is requested), when executing the first step (the `emv_startTransaction` method). Also note, the SDK has an “autoAuthenticate” option that is ON by default. If autoAuthenticate is set to ON before the EMV transaction begins, this authenticate transaction step will be bypassed. The main class has a method to set this Boolean: `emv_autoAuthenticate(bool authenticate)`.

The app should (as usual) monitor the `DeviceState` via the second argument of the `MessageCallBack` method (the method that was registered with the device at the time the app was loaded). Direct inspection of the `DeviceState` will tell you whether the callback is being called with device data, or with a state of `EMVCallback` (requiring a change of UI message, or perhaps interaction with the user), or with transaction data.

If the user is required to enter a PIN or interact in some other way with the app's UI, this is the stage during which such interaction will occur.

The final callback will have a `DeviceState` (second argument) of `TransactionData` and will be accompanied by a standard EMV result code conforming to one of the following:

```
public enum EMV_RESULT_CODE
    {
        EMV_RESULT_CODE_APPROVED_OFFLINE = 0,
        EMV_RESULT_CODE_DECLINED_OFFLINE = 1,
        EMV_RESULT_CODE_APPROVED = 2,
        EMV_RESULT_CODE_DECLINED = 3,
        EMV_RESULT_CODE_GO_ONLINE = 4,
        EMV_RESULT_CODE_CALL_YOUR_BANK = 5,
        EMV_RESULT_CODE_NOT_ACCEPTED = 6,
        EMV_RESULT_CODE_FALLBACK_TO_MSR = 7,
        EMV_RESULT_CODE_TIMEOUT = 8,
        EMV_RESULT_CODE_GO_ONLINE_CTLS = 9,
        EMV_RESULT_CODE_AUTHENTICATE_TRANSACTION = 16,
        EMV_RESULT_CODE_SWIPE_NON_ICC = 17,
        EMV_RESULT_CODE_CTLS_TWO_CARDS = 122,
        EMV_RESULT_CODE_CTLS_TERMINATE_TRY_ANOTHER = 125,
        EMV_RESULT_CODE_CTLS_TERMINATE = 126,
        EMV_RESULT_CODE_UNABLE_TO_REACH_HOST = 255,
        EMV_RESULT_CODE_FILE_ARG_INVALID = 4097,
        EMV_RESULT_CODE_FILE_OPEN_FAILED = 4098,
        EMV_RESULT_CODE_FILE_OPERATION_FAILED = 4099,
        EMV_RESULT_CODE_MEMORY_NOT_ENOUGH = 8193,
        EMV_RESULT_CODE_SMARTCARD_OK = 12289,
        EMV_RESULT_CODE_SMARTCARD_FAIL = 12290,
        EMV_RESULT_CODE_SMARTCARD_INIT_FAILED = 12291,
        EMV_RESULT_CODE_FALLBACK_SITUATION = 12292,
        EMV_RESULT_CODE_SMARTCARD_ABSENT = 12293,
        EMV_RESULT_CODE_SMARTCARD_TIMEOUT = 12294,
        EMV_RESULT_CODE_MSR_CARD_ERROR = 12295,
        EMV_RESULT_CODE_PARSING_TAGS_FAILED = 20481,
        EMV_RESULT_CODE_CARD_DATA_ELEMENT_DUPLICATE = 20482,
        EMV_RESULT_CODE_DATA_FORMAT_INCORRECT = 20483,
        EMV_RESULT_CODE_APP_NO_TERM = 20484,
        EMV_RESULT_CODE_APP_NO_MATCHING = 20485,
        EMV_RESULT_CODE_MANDATORY_OBJECT_MISSING = 20486,
        EMV_RESULT_CODE_APP_SELECTION_RETRY = 20487,
        EMV_RESULT_CODE_AMOUNT_ERROR_GET = 20488,
        EMV_RESULT_CODE_CARD_REJECTED = 20489,
        EMV_RESULT_CODE_AIP_NOT_RECEIVED = 20496,
        EMV_RESULT_CODE_AFL_NOT_RECEIVED = 20497,
        EMV_RESULT_CODE_AFL_LEN_OUT_OF_RANGE = 20498,
        EMV_RESULT_CODE_SFI_OUT_OF_RANGE = 20499,
        EMV_RESULT_CODE_AFL_INCORRECT = 20500,
        EMV_RESULT_CODE_EXP_DATE_INCORRECT = 20501,
        EMV_RESULT_CODE_EFF_DATE_INCORRECT = 20502,
        EMV_RESULT_CODE_ISS_COD_TBL_OUT_OF_RANGE = 20503,
        EMV_RESULT_CODE_CRYPTOGRAM_TYPE_INCORRECT = 20504,
        EMV_RESULT_CODE_PSE_BY_CARD_NOT_SUPPORTED = 20505,
        EMV_RESULT_CODE_USER_LANGUAGE_SELECTED = 20512,
        EMV_RESULT_CODE_SERVICE_NOT_ALLOWED = 20513,
        EMV_RESULT_CODE_NO_TAG_FOUND = 20514,
        EMV_RESULT_CODE_CARD_BLOCKED = 20515,
        EMV_RESULT_CODE_LEN_INCORRECT = 20516,
        EMV_RESULT_CODE_CARD_COM_ERROR = 20517,
        EMV_RESULT_CODE_TSC_NOT_INCREASED = 20518,
        EMV_RESULT_CODE_HASH_INCORRECT = 20519,
        EMV_RESULT_CODE_ARC_NOT_PRESENCED = 20520,
        EMV_RESULT_CODE_ARC_INVALID = 20521,
        EMV_RESULT_CODE_COMM_NO_ONLINE = 20528,
        EMV_RESULT_CODE_TRAN_TYPE_INCORRECT = 20529,
        EMV_RESULT_CODE_APP_NO_SUPPORT = 20530,
        EMV_RESULT_CODE_APP_NOT_SELECT = 20531,
        EMV_RESULT_CODE_LANG_NOT_SELECT = 20532,
        EMV_RESULT_CODE_TERM_DATA_NOT_PRESENCED = 20533,
        EMV_RESULT_CODE_CVM_TYPE_UNKNOWN = 24577,
        EMV_RESULT_CODE_CVM_AIP_NOT_SUPPORTED = 24578,
        EMV_RESULT_CODE_CVM_TAG_8E_MISSING = 24579,
        EMV_RESULT_CODE_CVM_TAG_8E_FORMAT_ERROR = 24580,
        EMV_RESULT_CODE_CVM_CODE_IS_NOT_SUPPORTED = 24581,
        EMV_RESULT_CODE_CVM_COND_CODE_IS_NOT_SUPPORTED = 24582,
        EMV_RESULT_CODE_CVM_NO_MORE = 24583,
        EMV_RESULT_CODE_PIN_BYPASSED_BEFORE = 24584
    }
```

If the result code at the end of the Authenticate Transaction stage is `EMV_RESULT_CODE_GO_ONLINE`, then the terminal app should go online to obtain final authorization. (Going online is the responsibility of the payment app, not the reader. The EMV kernel has no knowledge of online endpoints, protocols, or APIs.)

At the conclusion of Authenticate Transaction, the reader can call `emv_completeTransaction()` or `emv_cancelTransaction()`, as appropriate. For example, if the result of your online authorization request was a decline, you would call `emv_cancelTransaction()`, and terminate. If the online request was approved, you would call `emv_completeTransaction()`.

2.4 Complete Transaction

After going online for authorization, you can call `emv_completeTransaction()`. You should call this method even if you were unable to go online but still wish to proceed with the transaction. (You would do this, for example, if the network was down or the gateway failed to respond.)

You should provide the `emv_completeTransaction()` method with the parameters that tell it if you were able to successfully reach the approver. (These parameters should be provided in tag 8A. Typical values here are 0x3030 for approval, 0x3032 for referral, 0x3035 for decline, and 0x5A33 for "unable to go online.") Issuer Authentication Data (tag 91) and Issuer Scripts (tags 71 or 72) are not *required*, but if they were returned by the online approver, they should be passed to this method. Consult the SDK documentation for the method signature and calling conventions; also consult the sample demo app code for an actual example of how to use this method.

When the transaction is complete, the reader will invoke your `MessageCallBack` method with a `DeviceState` of `TransactionData`. The sample demo app code shows how to pull TLV (tag) data out of the `IDTTransactionData` object provided in the fourth argument to the callback. Typically, this tag data will include TVR and TSI data, in tags 95 and 9B, respectively.

Tags from the reader may contain masked and encrypted data. ID TECH encrypts some (but not all) tag data, using criteria described in ID TECH document 80000502-001, *ID TECH Encrypted Data Output*. The SDK has methods that will parse a TLV stream as necessary when the card data is returned, so manual parsing of the raw TLV data should not be required. Indeed, this is one advantage of using the Universal SDK: No matter whether your data is TLV data or magstripe data, the SDK has methods to parse it for you.

2.5 TLV Data

EMV transactions produce TLV data (data conforming to the BER-TLV tag/length/value convention; see Annex B, Book 3, EMV 4.3). At any stage in a transaction, you can use the `emv_unencryptedTags` field of your `IDTTransactionData` object (which has an instance name of `cardData` in the SDK sample code) to obtain unencrypted tags, or the `emv_encryptedTags` field to obtain encrypted tags. These fields point to byte[] arrays that you then need to process further, if you wish to obtain actual TLVs. For example, you can use a routine like the following to convert the byte arrays to a Dictionary from which you can obtain text versions of the TLVs:

```
private string tlvToValues(byte[] tlv)
        {
            string text = "";
            Dictionary<string, string> dict =
                  Common.processTLVUnencrypted(tlv);
            foreach (KeyValuePair<string, string> kvp in dict)
                  text += kvp.Key + ": " + kvp.Value + "\r\n";
            return text;
        }
```

2.5.1 Default Tags

Each stage of the transaction produces TLV data specific to the stage in question. The default TLVs obtained at each stage will vary somewhat by product, but the following are typically returned:

Start Transaction
4F
50
57
5A
5F20

5F24
5F25
5F2D
5F34
84
9F20
DFEE12
DFEE23

<u>Authenticate Transaction</u>
95
9B
9F02
9F03
9F10
9F13
9F26
9F27
9F34
9F36
9F37
9F4D
9F4F

<u>Complete Transaction</u>
95
99
9B
9F02
9F03
9F10
9F13
9F26
9F27
9F34
9F36
9F37
9F4D
9F4F
9F5B

Note that almost all of these are EMVCo-defined standard tags. ID TECH proprietary tags (typically three bytes in length, starting with DFEE or DFEF) sometimes also appear. For example, DFEE12 contains the transaction's KSN (Key Serial Number).

For a complete listing of ID TECH proprietary tags and their meanings, refer to document 80000503-001, *ID TECH TLV Tag Reference Guide*, available for download at https://atlassian.idtechproducts.com/confluence/display/KB/Downloads+-+Home.

2.5.2 Encrypted Tags

Some TLVs will contain encrypted data, if your device has been key-injected (and has encryption turned on). Generally speaking, any tags containing track data (56, 57, 9F6B) or PAN data (5A), or any other data considered sensitive, will be encrypted according to the rules spelled out in document 80000502-001-F, *ID TECH Encrypted Data Output*. (This document can be downloaded from the above web page.)

By default, the following tags (if present in your data) will be encrypted, assuming you are using a device that has been key-injected, with encryption enabled:

```
5A
56
57
9F1F
9F20
9F6B
FFEE13
FFEE14
DF812A
DF812B
DF31
DF32
```

2.5.3 Obtaining Extra Tags

Recall that you can (optionally) notify the card reader to produce extra tags by including a DFEE1A tag in your original call to `emv_startTransaction()`. See Start Transaction, further above. To obtain extra tags, first include a DFEE1A TLV in your call to `emv_startTransaction()` and/or `emv_authenticateTransaction()`, and/or `emv_completeTransaction()`. Then, after each phase has finished, you can call `emv_retrieveTransactionResult()` to retrieve the requested TLVs.

> NOTE: You must call `retrieveTransactionResult()` within 15 seconds after the transaction is over. For security reasons, this data is not persisted in memory for an extended period of time after the transaction completes.

IMPORTANT: When you specify additional tags in `emv_startTransaction()`, these are the *only* tags you can expect to retrieve. The default set of EMV tags will be overridden by your request for other tags.

Also note: Tags 57 and 5A are available after `emv_startTransaction()` by default (as indicated further above), but are *not* included by default after `emv_authenticateTransaction(),` or `emv_completeTransaction()`.

3 Additional Resources

You can find a variety of technical resources (white papers, SDKs, demos, utilities, documentation) on EMV-based application development at the ID TECH Knowledge Base: https://atlassian.idtechproducts.com/confluence/display/KB/EMV+tools+and+reference+-+downloads. No registration is required. Downloads are free and unlocked.

On the Knowledge Base, you'll find ID TECH document 80000502-001, *ID TECH Encrypted Data Output*. This document is invaluable for understanding how ID TECH readers package MSR and EMV data.

A contact-EMV sample application with source code can be found at https://atlassian.idtechproducts.com/confluence/download/attachments/30479625/Contact%20EMV%20Demo%201.00.zip?api=v2. This Windows-based app, written in C#, illustrates the programming idioms commonly used in EMV payment applications that take advantage of the Universal SDK.

Revision History

Rev.	**Date**	**Change**	**Author**
50	9/19/2016	Initial draft.	KT
A	11/16/2016 1/3/2017 2/17/2017	Add Initializations section (and sub-sections on Terminal Configuration, AIDs, and CAPKs), with code examples. Include discussion of obtaining extra tags. Add internal links. Add section on Stand-In Processing (unable to go online). Expand discussion of Gen AC choreography.	KT KT KT
B	8/10/2017	Add explicit listing of encrypted tags. Add "Additional Resources" section. Expand discussion of Terminal Configurations. Add reference to contact-EMV sample app. Various clarifications.	KT