

**Aculab Prosody™ 2 (TiNG)**

**T.38 Gateway introduction.**

Revision 1.0





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# 1 Introduction

This document provides background information for developers constructing applications that are to make use of the Aculab T.38 Gateway.

It should be read in conjunction with the Aculab T.38 Gateway API guide [2] and the Aculab T.38 Gateway logging description [3].

Some familiarity with the T.30 [5] fax protocol and its messages (TCF, MCF etc.) is assumed - this is especially the case in order to interpret log output arising from the T.38 Gateway.

## 1.1 T.38 Fax Relay

T.30 fax was designed for analogue networks. If fax must be conveyed over an IP network and the simple approach of carrying the audio signals over a VoIP/RTP circuit is taken then problems can arise linked to packet loss, jitter, resyncs and latency. Furthermore relatively high bandwidth G.711 coded RTP will be required as use of more advanced (voice specific) VoIP codecs is likely to deform fax modem signals. Finally T.30 fax requires tight timing tolerances that are difficult to maintain across a WAN.

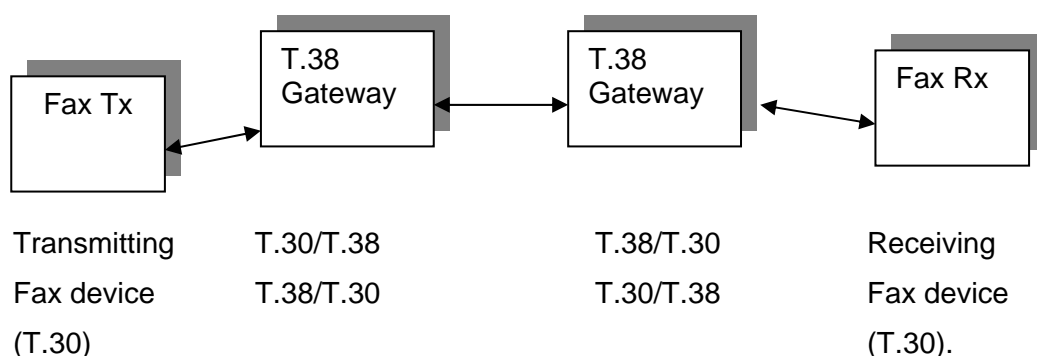
In response to the above problems the T.38 fax relay recommendation [4] was devised in 1998 as a way to permit faxes to be transported across IP networks between existing Group 3 (G3) fax terminals. The data payload is extracted from the audio (T.30) analog output of the transmitting fax device, encoded using T.38 and sent across the network, then re-constituted as an audio (T.30) analogue signal and presented to the receiving fax device.

There must exist at the edges of the IP network devices or systems responsible for T.30 / T.38 protocol conversion. A T.38 Gateway fulfills this function.

## 1.2 T.38 Gateway

Telecommunications Gateways, (*also called **protocol converters***), convert one protocol stack into another. The job of a gateway is to convert protocols among communications networks. A router transfers, accepts and relays packets only across networks using similar protocols. A gateway on the other hand accepts data formatted for one protocol and converts it to another protocol before forwarding.

In a T.38 telecommunications gateway conversion is from T.30 to T.38 and from T.38 to T.30.



**Figure 1 T.38 Gateway positions.**

## 2 The Aculab T.38 Gateway

The Aculab T.38 Gateway consists of a software library that is linked into a customer application running on a Linux or Windows host. Typically this application will handle voice calls and will use the T.38 library for processing fax transfers originating from these voice calls. Both the application and the T.38 Gateway library access Prosody X card functionality using the standard TiNG API. Interfacing to the T.38 Gateway library however is *only* via the T.38 Gateway API [2].

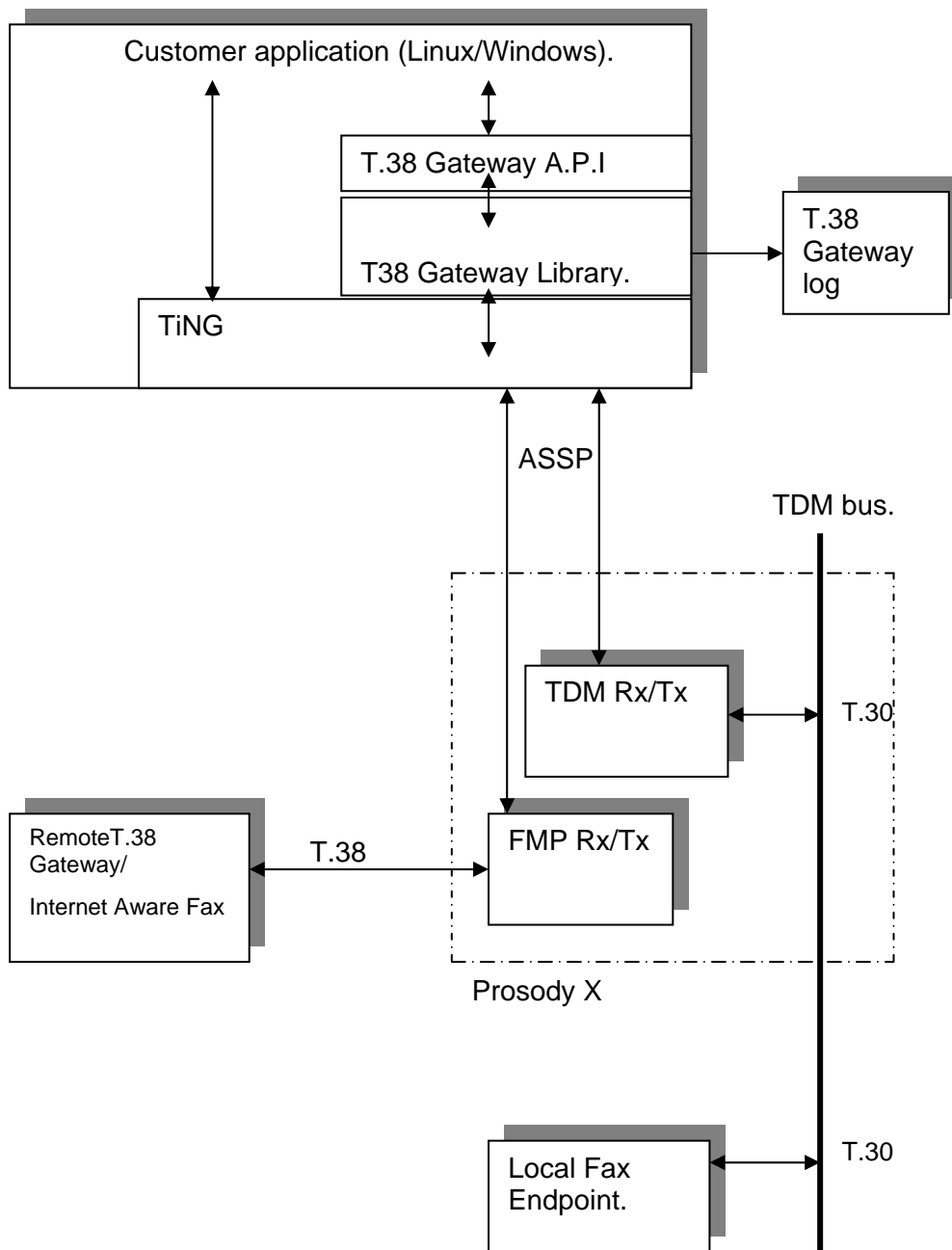


Figure 2. System layout (TDM option)

Figure 2 shows a system application layout including the T.38 Gateway library using TDM for the T.30 connection. The T.38 Gateway library controls TDM and FMP rx and tx objects running on a Prosody X card. The FMP (Fax Media point) objects encode and decode T.38 data. A list of firmware modules that are required to be loaded to each Prosody X module used by the T.38 Gateway can be found in [2].

The Aculab T.38 Gateway transfers fax transaction data on both directions from the fax transmitter to the fax receiver mostly without alteration of data payload or significant alteration of timing. Data payload is only altered for the DIS and NSF V.21 fax control fields (FCF) to enforce T.38 Gateway user options and prevent the use of non-standard protocols (2.9) [3].

The Aculab T.38 Gateway enforces certain HDLC protocol constraints and data timings required for inter-working with various third party T.38 Gateways and Adapters.

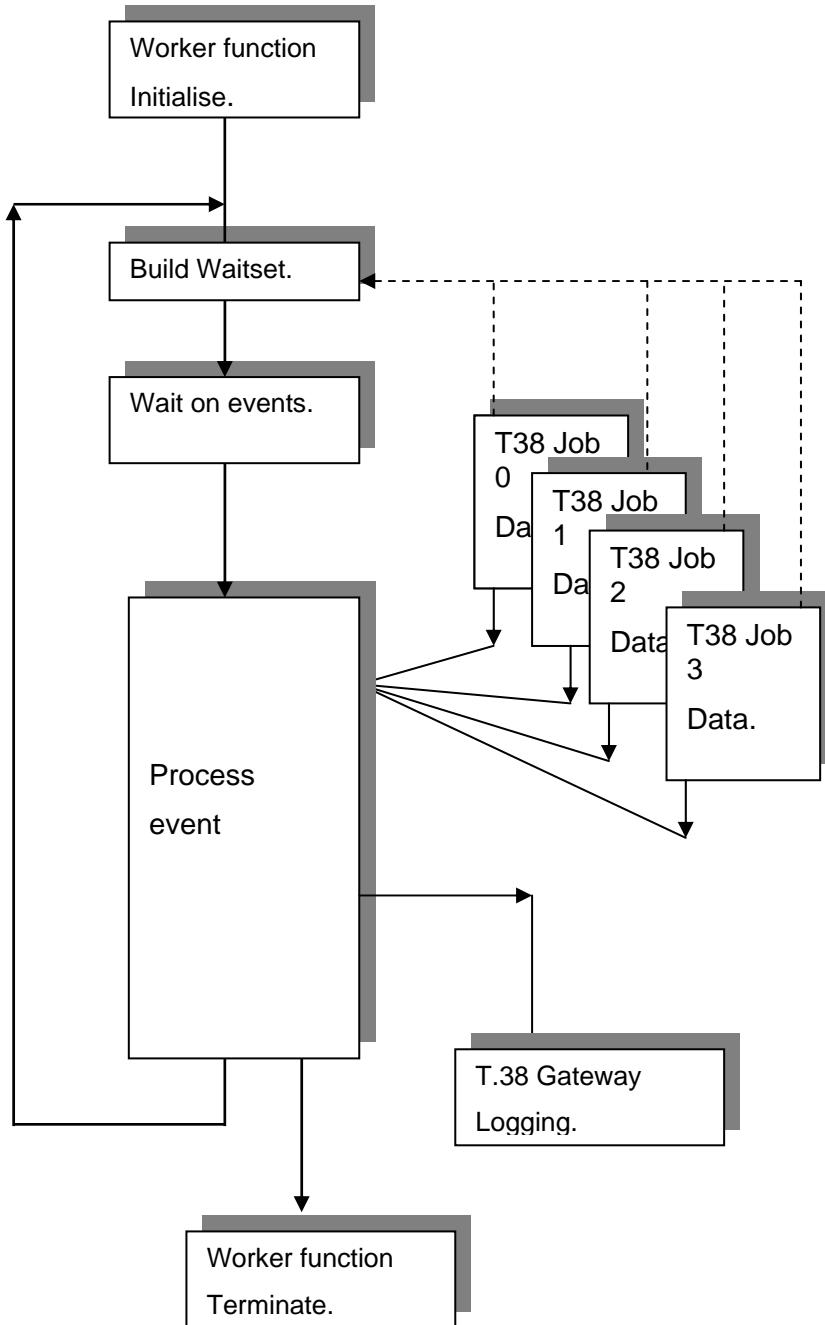
The T.30 side of the Aculab T.38 Gateway can be set up to work with either TDM transported signals, or VoIP/RTP transported signals. In the latter case fax transfers are susceptible to all of the issues listed in 1.1 and therefore this option should only be used with local reliable networks.

The T.38 Gateway library provides comprehensive logging functionality intended for use in system development and diagnosis [3].

## 2.1 Session and worker functions

All fax transactions are handled by T.38 Gateway jobs (2.4), a fax transaction is a full or partial transfer of a single or multi-page fax across the T.38 Gateway. T.38 jobs are created and are added to a *session* by the application using the appropriate API calls. T.38 jobs exist for the life of one fax transaction only and are then deleted from the session by the T.38 Gateway library when the transaction terminates.

A session manages a set of T.38 Gateway jobs, these jobs are processed by a worker function. Every session created must also have an associated worker function.



**Figure 3 Worker function and session data.**



## 2.2 Session creation and worker start

Applications must create at least one T.38 Gateway session/worker function that must exist for the duration of the T.38 Gateway activity.

A session is created with the API function *sm\_t38gw\_create\_session*, the worker function *sm\_t38gw\_worker\_fn* is started in a separate thread created and run by the application.

Each session can manage up to six T.38 Gateway jobs so an application may create sessions dynamically when needed or create enough session to accomodate maximum number of concerrent jobs at program initialisation. Session creation is logged to the T.38 Gateway log.

## 2.3 Session stop and session destroy

Session removal is a two stage process, first the session is stopped using the API function *sm\_t38gw\_stop\_session*. This API call results in a shutdown of all T.38 Gateway jobs being handled by the session. These T.38 jobs are terminated by the T.38 Gateway library as fast as possible hence all active fax transactions will be interrupted and fail.

When all t38gw jobs have been terminated the worker function will terminate.

Once the worker function has terminated the session can be destroyed with the API function *sm\_t38gw\_destroy\_session*.

### NOTE

The session must not be destroyed until the worker function has returned.

## 2.4 T.38 Gateway jobs

Fax transactions are handled by T.38 Gateway jobs, a fax transaction is a full or partial transfer of a single or multi-page fax across the T.38 Gateway.

Each T.38 Gateway job requires a fully configured FMP rx/tx pair and TDM (or VMP) rx/tx pair created on the same Prosody X card module. The configuration information is derived from the SIP exchange (2.12) and application preferences.

A T.38 gateway job is created by the API call *sm\_t38gw\_create\_job*. It is added to a session by the API call *sm\_t38gw\_add\_job*.

T.38 jobs exist for the life of one fax transaction only and are then deleted from the session by the T.38 Gateway library when the transaction terminates (2.13).

The application is notified of progress of the fax transaction by the notify function (2.7), and can obtain the status of a T.38 job at any time with the T.38 Gateway job status function (2.6).

## 2.5 VMP,TDM,FMP Lifetime and Ownership

Before a T.38 Gateway job can be created and added to a session a FMP rx/tx pair and TDM (or VMP) rx/tx pair must be created and configured.

Following successful T.38 gateway job creation and addition of job to a session ownership of the FMP/TDM/VMP pairs is passed to the T.38 Gateway library.

### NOTE

Once the job has been started, the application must not access any FMP/TDM/VMP associated with the T.38 job during the period of the fax transaction.

The application obtains the status of the T.38 Gateway job through using the notify function and the API call *sm\_t38gw\_job\_status* call. When this indicates T.38 job has terminated, ownership of the FMP/TDM/VMP is returned to the application which may now destroy them.

## 2.6 T.38 Gateway job status

The API call *sm\_t38gw\_job\_status* provides the application with the status of an individual T.38 Gateway job. It can be called at any time and in any thread of execution.

### NOTE

It should not however, be called within the job notify function (2.7) as this will result in a deadlock situation.

## 2.7 T.38 Gateway callback function

The purpose of the callback function is to inform the application of image page conformation and job termination events occurring during the fax transaction. The callback function is customer implemented with the following prototype.

```
(void)*job_notify(SM_T38GW_JOB_CONTEXT_PARMS *job_context)
```

The callback is called by the worker function (2.2) and therefore should be as lightweight as possible in order to avoid delaying processing of all current T.38 jobs managed by a session. Typically the callback function is only used to set an event that stimulates the application to call *sm\_t38gw\_job\_status* (an event handle can be stored in user\_id field of SM\_T38GW\_JOB\_CONTEXT\_PARMS)

### NOTE

*sm\_t38gw\_job\_status* should not be called within the job notify function as this will result in a deadlock situation.

The callback function will be invoked when a page conformation is received from the fax receiver (T.30 MCF) and when the T.38 Gateway job terminates.

## 2.8 Fax direction

T.38 Gateway jobs should be configured for one of the only two valid configurations, Gateway A (*image to network*) where the fax image is received from T.30 and sent to T.38 and Gateway B (*image from network*) where the fax image is received from T.38 and sent to T.30. This requires the fax direction to be determined before the creation of the T.38 job.

Both configurations are described in [2] [3] and a summary of the ‘local’ and ‘remote’ endpoint options for both configurations is provided in Figure 4.

### TDM option.

	Gateway A	Gateway B
Local Endpoint	<i>TDM</i>	<i>FMP</i>
Remote Endpoint	<i>FMP</i>	<i>TDM</i>

### VMP option.

	Gateway A	Gateway B
Local Endpoint	<i>VMP</i>	<i>FMP</i>
Remote Endpoint	<i>FMP</i>	<i>VMP</i>

**Figure 4 T.38 job local, remote configuration options.**

Other combinations of local and remote endpoints are possible but they are reserved for Aculab test purposes only.

T.38 job configuration is easily checked from the T.38 Gateway log [3]. Incorrect T.38 Gateway configuration is one of the main causes of problems during application development.

A method of determining fax direction prior to configuring and starting a T.38 Gateway job is by CNG [5] tone detection. A series of CNG tones are emitted by a fax transmitter at the start of the sequence these being terminated when a response is received from the fax receiver.

The single CED [5] tone sent by a fax receiver is an unreliable indication as it is easily missed.

Once a T.38 Gateway job is started however, it will process a fax transaction with or without tones and pass on any received CNG or CED tones.

## 2.9 Modems

The T.38 Gateway supports V.17, V.29 and V.27ter at all speeds (Figure 5). The API guide describes how to disable the use of V.17 and or V.29 during T.38 job creation. The disabling of V.17 and even V.29 may be appropriate in the case of 'bad line' conditions where the use of a slower less complex modem decreases the failure rate of fax transfers. It is not possible to limit the maximum speed of any modem used by the T.38 Gateway. The T.38 Gateway log displays the enabled modems when the T.38 job is started and the negotiated modem and speed on receipt of a DCS or CTC from the receiving fax endpoint.

Fax endpoints often train down to lower speeds and modems in response to poor TCF or image reception quality. The T.38 Gateway follows fax endpoint train down over the complete range of modems and speeds.

Speed(bps)	V.17	V.29	V.27ter
14400	XX		
12000	XX		
9600	XX	XX	
7200	XX	XX	
4800			XX
2400			XX

**Figure 5 Modem speeds.**

The TCF [5] sent during negotiation or during train-down on poor image reception, consists of 1.5 seconds of zeros sent as image data by the fax transmitter. The fax receiver uses the 'quality' of the received TCF to produce a Conformation to receive (CFR) or a Failure to train (FTT) [5]. Because of this the Aculab T.38 Gateway supports the '*TransferredTCF* ( 2.12.1) option only.

## 2.10 ECM disable

The use of ECM (Error Correction Mode) during a fax transfer is advantageous as it uses HDLC encoding allowing Partial Page Request (PPR) retransmission of corrupted HDLC frames, and speed drop without re-training.

The T.38 Gateway cannot impose use of ECM upon the two fax endpoints but it can be configured to inhibit it's use if required for testing or other purposes.

## 2.11 FSK tx power

A feature is provided to allow transmission of reduced power FSK signals by the gateway on its T.30 side. This can sometimes prove useful when it is necessary to avoid echo reflections of FSK in networks where these echos occur after an abnormally long delay disrupting the smooth operation of the T.30 protocol.

## 2.12 SIP parameters

A correct correspondence between the parameters of the SIP re-invite prior to start of T.38 gateway job and the configuration of that job is important in order to avoid interoperability problems between gateway and its T.38 peer. The following sections describe parameters that are critical to correct operation, less well defined parameters, and parameters not supported by gateway.

### 2.12.1 Critical SIP parameters

#### **T38FaxVersion (asn1)**

Mismatch of T38FaxVersion is a major source of problems in the T.38 Gateway. A mismatch can cause undefined behaviour particularly in the early stages of the fax sequence. It is for this reason that the asn1 version used by each T.38 Gateway job is outputted to the T.38 Gateway log [3] to allow easy verification.

The T38FaxVersion contained in the incoming T.38 SDP must be used to configure the FMP tx (2.5). And the T38FaxVersion contained in the outgoing T.38 SDP must be used to configure the FMP rx (2.5).

#### **T38FaxRateManagement**

The Aculab T.38 Gateway supports only 'TransferredTCF' that is the T.38 Gateway does not generate a TCF (2.9).

**T38FaxUdpEC** t38UDPRedundancy **only**.

### 2.12.2 Less Well Defined SIP parameters

#### **T38FaxMaxBuffer**

Indicates the maximum number of octets that can be stored before an overflow condition occurs. Parameter value for the Aculab T.38 Gateway is defined in [2]. TiNG however, allocates an 8k buffer per input channel.

#### **T38FaxMaxDatagram:**

There does not seem to be a precise definition as to exactly what this includes but general consensus is that it excludes RTP header and redundancy. The gateway API includes a call to set maximum payload size for generated T.38 packets, *sm\_t38gw\_set\_job\_mpl* [2], which can be used to set a suitable value.

### 2.12.3 Unsupported SIP parameters

The T.38 Gateway does not support the following SDP parameters, exclusion of these from a SDP should be interpreted as false (not supported).

#### **T38FaxFillBitRemoval.**

Indicates the capability to remove and insert fill bits in Phase C, non-ECM data to reduce bandwidth.

#### **T38FaxTranscodingMMR.**

Indicates the ability to convert to/from MMR from/to the line format for increasing the compression of the data and reducing the bandwidth.

#### **T38FaxTranscodingJBIG.**

Indicates the ability to convert to/from JBIG to reduce bandwidth.

## 2.13 T.38 job termination

T.38 Gateway jobs are terminated by a DCN from either fax endpoint or by the application calling *sm\_t38gw\_abort\_job* [2]. The API call *sm\_t38gw\_abort\_job* can be invoked at any time and in any thread of execution.

### **NOTE**

It should not however, be called within the job notify function (2.7) as this will result in a deadlock situation.

In all cases T.38 Gateway jobs shutdown using the stop sequence.

There is no guarantee that a fax transaction will include a DCN and therefore result in termination of the T.38 Gateway job.

### 3 Example sequences

Two example sequences are presented here, the first is for a successful fax transfer with the second an incomplete one requiring an abort of the T.38 Gateway job. These sequences are included only to clarify the function of the various components involved and therefore should not be regarded as anything other than this.

#### 3.1 Successful fax transfer

Application sets up a voice call on one of it's channels.

[Application](#)                      [T.38 Gw library.](#)                      [Application event handler.](#)

CNG detected (2.8)

SIP Re-invite (2.12)

Create FMP and TDM (2.5)

Configure FMP and TDM (2.5)

sm\_t38gw\_create\_job() (2.4)

sm\_t38gw\_add\_job() (2.4)

event (2.7)

sm\_t38gw\_job\_status()(2.6) =  
*tSMT38GWJobStatusRunning*  
(image page 1).

event

sm\_t38gw\_job\_status() =  
*tSMT38GWJobStatusRunning*  
(image page 2).

event

sm\_t38gw\_job\_status() =  
*tSMT38GWJobStatusRunning*  
(image page 3).

event

sm\_t38gw\_job\_status() =  
*tSMT38GWJobStatusTerminated* (2.13)  
Delete FMP and TDM (2.5)

Voice call terminates.

### 3.2 Incomplete fax transfer

Application handling voice calls detects a CNG on one of the active calls however, the call drops during the transfer of the third page.

Application sets up a voice call on one of it's channels.

[Application](#)                      [T.38 Gw library.](#)                      [Application event handler.](#)

CNG detected (2.8)

SIP Re-invite (2.12)

Create FMP and TDM (2.5)

Configure FMP and TDM (2.5)

sm\_t38gw\_create\_job() (2.4)

sm\_t38gw\_add\_job() (2.4)

event (2.7)

sm\_t38gw\_job\_status()(2.6) =  
*tSMT38GWJobStatusRunning*  
(image page 1).

event

sm\_t38gw\_job\_status() =  
*tSMT38GWJobStatusRunning*  
(image page 2).

Call dropped, connection broken.

sm\_t38gw\_abort\_job()(2.13)

event

sm\_t38gw\_job\_status() =  
*tSMT38GWJobStatusTerminated* (2.13)  
Delete FMP and TDM (2.5)



## 4 Resource Management

Standard TiNG profiling procedures should be used to evaluate channel count for gateway use of a given TiNG module in context of customer application. It should be noted fax relay from T.30 TDM/VMP to T.38 FMP is computationally more expensive than the reverse type of fax relay (as a V.17 receiver is more expensive than a V.17 transmitter).

## 5 Fax spoofing

Spoofing in a T.38 Gateway refers to the modification of the protocol, commands or responses on the T.30 side to keep network delays on the IP side from causing the fax transaction to fail. Spoofing a fax transaction is only required where network round trip times approach the T.30 fax protocol timeout of 3 seconds.

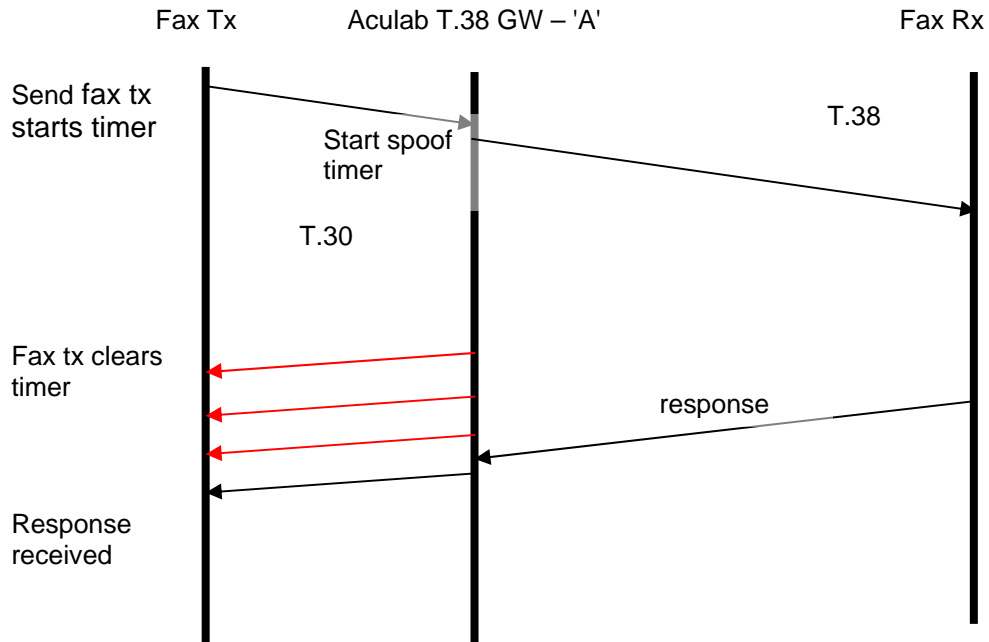
The Aculab T.38 Gateway implements spoofing in both Gateway A and Gateway B (2.8) with Gateway A spoofing the fax transmitter and Gateway B spoofing the fax receiver.

Spoofing in the Aculab T.38 Gateway is not activated for fax transactions on networks with a round trip delay of less than 2.5 Seconds. The T.38 Gateway log [3] will include logging output for spoofed T.38 Gateway jobs.

For test purposes spoofing can be disabled when a T.38 Gateway job is created by the API call `sm_t38gw_create_job` [2] [3] (2.4).

### 5.1 T.38 Gateway 'A' spoofing

Since path B Tx is V.21 only, spoofing uses V.21 HDLC [1] flags, this causes the fax transmitter to reset its transmit timer preventing a failure. When spoofing the Aculab T.38 Gateway sends HDLC flags only up to the point that the response is received from the fax receiver. This is to minimise the delay as seen by the fax receiver.



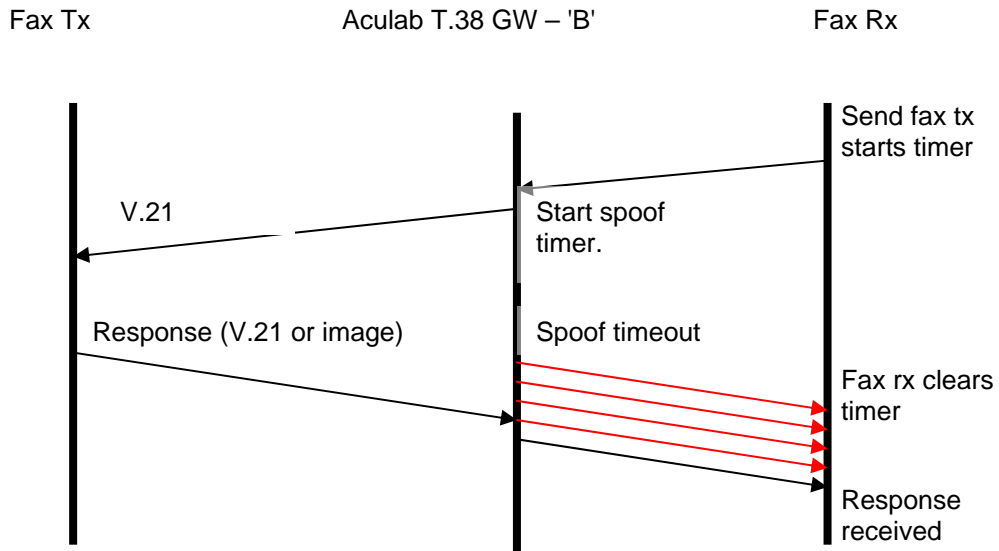
**Figure 6 T.38 Gateway 'A' T.30 spoofing.**

If a response is not received from the fax receiver then the spoof flag send sequence is terminated. The fax transaction will then either fail or the transmitter will repeat the command.

## 5.2 T.38 Gateway 'B' spoofing

Path A Tx is the image path transmitting V.21 and fast data. Fast image data can be ECM ( 2.10, 1.1) or sync. [1] hence the spoofing data can be :-

1. V.21 HDLC [1] flags,
2. Image HDLC flags,
3. Image Sync spoof data.



**Figure 7 T.38 Gateway 'B' T.30 spoofing.**

Spoof data causes the fax receiver to reset its timer preventing a failure. When spoofing the Aculab T.38 Gateway sends spoof data only up to the point that the response is received from the fax receiver. This is to minimise the delay as seen by the fax transmitter.

If a response is not received from the fax receiver then the spoof send sequence is terminated. The fax transaction will then either fail or the transmitter will repeat the command.

## 6 Troubleshooting

Diagnosing problems with a T.38 Gateway application can be difficult for a variety of reasons. First the T.30 recommendation [5] is old and in places vague. Fax endpoints and T.38 Gateways often loosely implement this and the T.38 recommendation [4] resulting in at best unexpected behaviour and at worst requiring a work-around.

A further difficulty is that the endpoints may not be accessible and in many cases will be unknown. Fax requires tight timing tolerances, introduction of a WAN between two fax endpoints will result in changes in signal timing (1.1). Legacy telecommunications equipment can also cause problems due to delay.

The main diagnostic tool for the T.38 Gateway is the T.38 Gateway log [3], in the majority of cases this will be all that is required. It may however, be necessary to capture the audio signals and packet streams sent to and received from the T.38 Gateway. This can be achieved using the locrec tool [10] supplied with TiNG, and standard packet capture tools such as Wireshark or tcpdump.

## 7 References

- [1] Prosody data communications Encodings: HDLC.
- [2] T.38\_Gateway\_API\_guide.
- [3] T.38 Gateway logging.
- [4] T.38 <http://www.itu.int/rec/T-REC-T.38/e>
- [5] T.30 <http://www.itu.int/rec/T-REC-T.30/en>
- [6] V.21 <http://www.itu.int/rec/T-REC-V.21/en>
- [7] V.17 <http://www.itu.int/rec/T-REC-V.17/en>
- [8] V.29 <http://www.itu.int/rec/T-REC-V.29/en>
- [9] V.27ter <http://www.itu.int/rec/T-REC-V.27ter/en>
- [10] locrec Prosody installation guide: test programs: locrec.

## 8 Glossary.

API	Application Programming Interface.
ASSP	Application Specific Standard Protocol.
CTC	Continue to Correct.
DCN	Disconnect.
DCS	Digital Command Signal.
DIS	Digital Identification Signal.
ECM	Error Correction Mode.
FMP	Fax Media Point.
FSK	Frequency Shift Keying.
IP	Internet Protocol.
NSF	Non Standard Facilities.
RTN	Retrain Negative.
RTP	Retrain Positive.
SDP	Session Description Protocol.
SIP	Session Initiation Protocol.
TDM	Time Division Multiplex.
VMP	Voice Media Point.
VOIP	Voice Over IP.