FaxTop™ 120
Technical White Paper

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Abstract

This paper discusses the technical aspects of the FaxTop   120 product line produced by Intisoft Asia Ltd.

Executive Summary

With the growing popularity of Internet, a lot of companies are migrating their I/T infrastructure to the Internet (TCP/IP) platform in order to take advantage of the various benefits provided by the technology. While the TCP/IP protocol suite has many different applications, online communications is by far the most important one. Ranging from Email to video conferencing, it enables the users to communicate effectively over the net. Since the "electronic correspondence" takes place over the data network and bypasses the more expensive Public Switched Telephone Network (PSTN), it provides a significant financial benefit to the companies.

In a lot of situations, however, traditional telephones and facsimile machines are still the preferred media of communication. The cost involved in upgrading/purchasing computer equipment and user training is usually too inhibiting for small and medium sized companies to make the transition to the Internet. Even with proper equipment and training, many people still prefer to fall back to telephones and fax machines, simply because that is what they have been doing for decades and feel most comfortable with. Given all these factors, it is generally believed that Internet messaging technologies will never replace telephones and fax machines, at least not in the foreseeable future.

Companies who have already invested heavily into the Internet want to maximize their returns. On the other hand, companies who are not currently online also want to realize the cost benefit provided by the Internet. This has created a new and exciting area of technology --- the unification of Internet and traditional messaging systems. The goal is to combine the best of both worlds. It lets users continue to use traditional messaging devices so that they don't have to learn anything new, at the same time, uses the Internet as the underlying carrier transport in order to take advantage of its substantially lower costs.

According to the Pitney Bowes/Gallup survey, there are about 70 million fax machines worldwide today. An average Fortune 500 company spends between $15 and $20 million annually for telecommunications services, of which 40% is for fax transmissions. Furthermore, the fax transmission business is predicted to increase by more than 20% per year over the next four years.

It is obvious that fax machine is a perfect candidate to get "connected" to the Internet. Intisoft has developed FaxTop™ to fulfill the need of combining Internet with facsimile machines.

Introduction

FaxTop™ uses the Internet to create toll-free real-time fax transmission. It connects a standard fax machine to any IP based network, either through an Ethernet or a modem dialup connection. There is virtually no training involved. After a few simple configurations via the fax machine keypad, users simply operate the fax machine the same as before. To send a fax, first punch in the receiving FaxTop™'s phone number, wait for the receiving end to answer the call. Then press the "START" button on the fax machine and the transmission will begin. The only difference is that the transmission will now go through the Internet, hence no expensive long distance telephone call is involved.

FaxTop™ is the perfect Internet faxing enabler for corporations with multiple sites and for service providers who wish to market and resell Internet faxing technology. Its main features includes:

- Real-time fax transmission over any IP based network

- No change in other fax functionality

- Simple operation via keypad on the fax machine and a LCD display on the FaxTop™ unit

- Patent-pending Network Congestion Control algorithm for reliable fax transmission under heavy Internet traffic

- Patent-pending Remote Ring Wakeup technology for Dialup to Dialup without the need of dedicated Internet connection

- IP address resolution via LDAP directory look-up

- Secure fax transmission

System Overview

Installation is a snap with the FaxTop™. Instead of connecting to a telephone outlet, the fax machine will be hooked up to the FaxTop™. The original telephone/fax line will also be connected to the FaxTop™. For the Dialup version (FT120D), an additional phone line is plugged into the FaxTop™'s built-in data modem. It automatically connects to the Internet through PPP dialup. For the Ethernet version (FT120E), a UTP cable is plugged into the FaxTop™'s built-in Ethernet network interface card. It accesses the Internet/Intranet through an existing LAN/WAN.
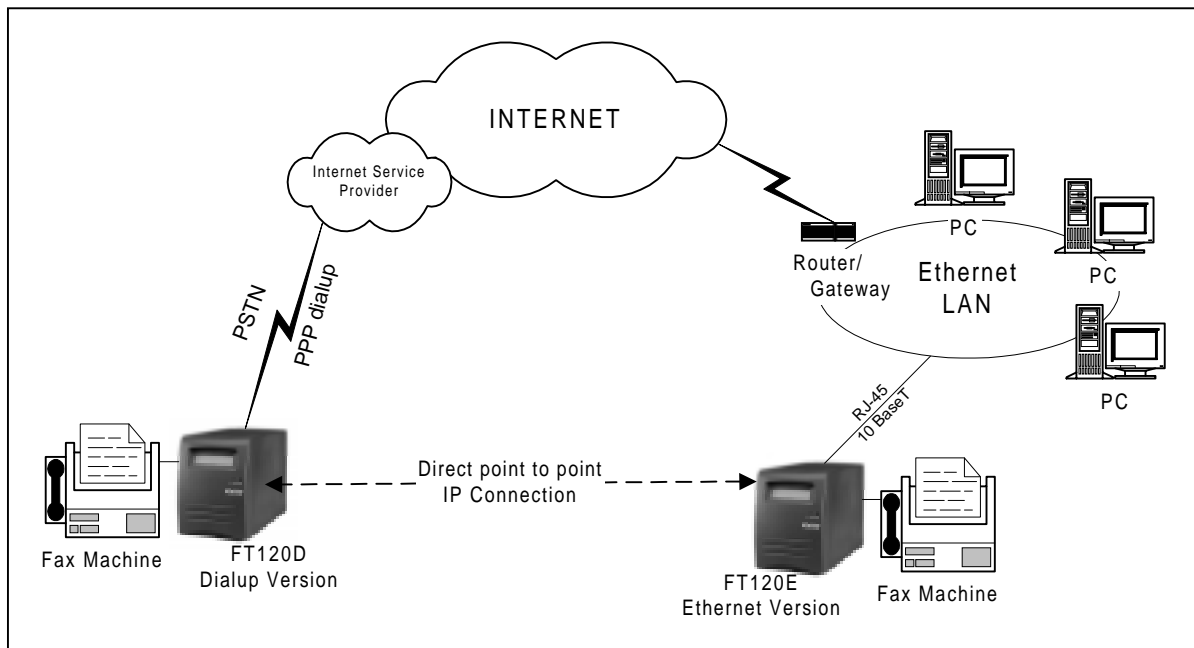
FT120 Setup Overview


Technology Highlights

The section describes each of the FaxTop™ 's unique features in more details.

Real-time Transmission

Real-time transmission is a very critical feature for any Internet faxing technology to be successful and accepted by the general public. A lot of Internet faxing products currently on the market are actually based on email protocol, transmission is done in a stored and forward fashion. As a result, users are not able to obtain immediate confirmation as to when the receiver has received the fax. In addition, if the fax delivery was not successful, for example, the receiving fax machine ran out of paper, the sender will not know to re-submit the fax until much later in time. This is a very significant deviation from what people are accustomed to when sending faxes through PSTN, and that is why most of these Internet faxing products have only accomplished limited success.

FaxTop™ enables real-time fax transmission through Internet. The fax document is sent directly from one machine to the other, there will be immediate confirmation for the delivery. If the transmission is unsuccessful, the user will get the notification right a way, so that s/he knows to send it again. From the user's perspective, it works exactly as if the transmission was done through PSTN.

During fax transmission, the on-ramp FaxTop™ (the one connected to the sending fax machine) captures the data from the fax machine, turns the data into IP packets, and continuously sends them over to the off-ramp FaxTop™ (the one connected to the receiving fax machine) through the Internet/Intranet. At the same time, the off-ramp FaxTop™ reassembles the packets back to the original data so that the fax machine can print it out. The following diagram gives a high level view of the protocol exchange in a typical FaxTop™ operation.
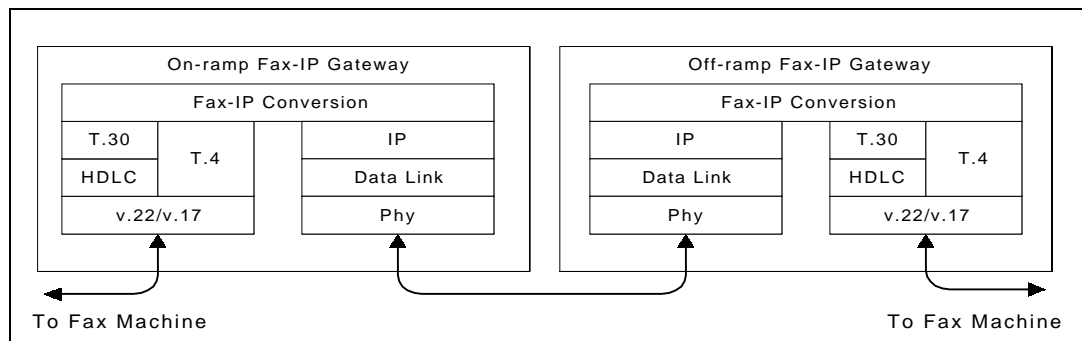
Real-Time Fax Over IP Protocol Stacks

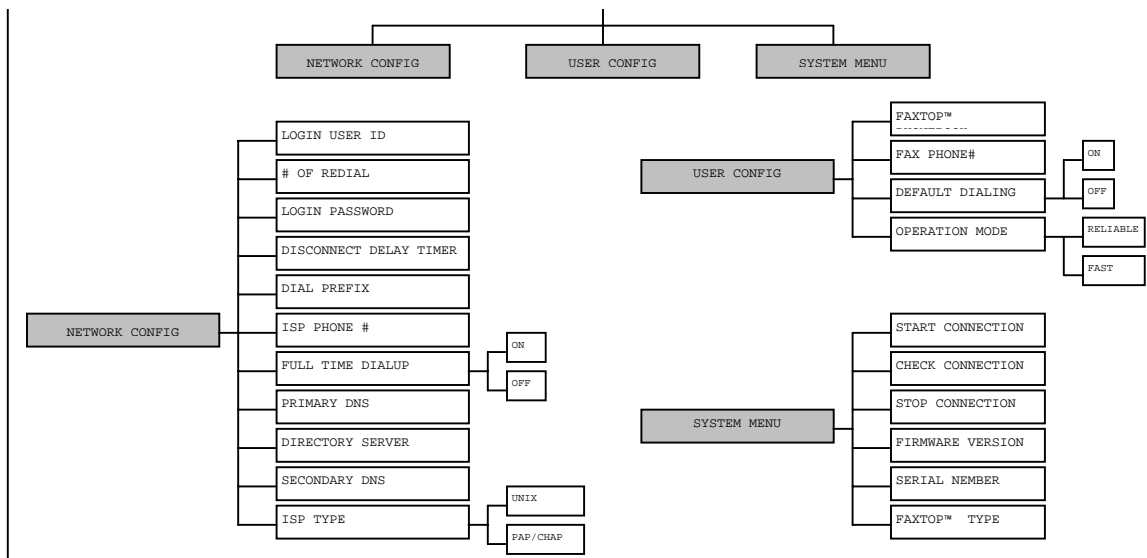## No Change In Other Fax Functionality

FaxTop™ is simply an add-on to the fax machine, it does not take any existing functionality away. The fax machine can still send faxes through regular telephone line if the user chooses to. By pressing the '#' key, the fax machine will be switched to the outside telephone line and then transmission will be done through the PSTN. FaxTop™ also has a feature called "Default Dialing". Once the option is turned on, FaxTop™ will automatically use outside line for transmission if the receiving fax machine is not equipped with a FaxTop™ .

Similarly, as soon as the FaxTop™ detects an incoming call from the outside line, it will automatically pass the call on to the fax machine so that it can receive the fax.

Simple Operation

FaxTop™ uses a LCD display (16 characters X 2) to provide users with operation status and acknowledgement information. All operation is done through the keypad on the fax machine. FaxTop™ intercepts every key pressed (DTMF tones) from the fax machine and performs the appropriate functions accordingly. To send fax, users simply enter the receiving FaxTop™ 's phone number, wait for the sending and receiving FaxTop™ to establish a connection, then press the "START" button to initiate transmission. Therefore, users can treat it just like a normal fax machine.

FaxTop™ also provides a simple and effective user interface through the LCD display. The menu system is constructed in a hierarchical fashion and users simply use the keypad to navigate it. The menu is mostly for configuration purposes, eg. ISP dial-in phone number, primary and secondary DNS, etc. Alpha characters can be entered through the numeric keypad. One can choose to use the 2-digit-combination scheme (eg. 2-1 for 'a', 2-2 for 'b') or the on-screen keyboard.

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NETWORK CONFIG | USER CONFIG | SYSTEM MENU

NETWORK CONFIG
- LOGIN USER ID
- # OF REDIAL
- LOGIN PASSWORD
- DISCONNECT DELAY TIMER
- DIAL PREFIX
- ISP PHONE #
- FULL TIME DIALUP → ON / OFF
- PRIMARY DNS
- DIRECTORY SERVER
- SECONDARY DNS
- ISP TYPE → UNIX / PAP/CHAP

USER CONFIG
- FAXTOP™
- FAX PHONE#
- DEFAULT DIALING → ON / OFF
- OPERATION MODE → RELIABLE / FAST

SYSTEM MENU
- START CONNECTION
- CHECK CONNECTION
- STOP CONNECTION
- FIRMWARE VERSION
- SERIAL NEMBER
- FAXTOP™ TYPE

FaxTop™ 120 Menu Hierarchy

Network Congestion Control

PSTN is a circuit-switched (also known as connection oriented) network, implying that a dedicated circuit is setup for each connection. Since fax machine is originally designed to work on PSTN, the fax communication protocol (T.30) assumes the characteristics of a circuit-switched network such as dedicated connection, guaranteed bandwidth, and guaranteed signal reproducibility including delay and jitter. Timing is very critical during fax transmission, the image data has to be streaming continuously from the sending side to the receiving end without any pauses or interruption. Fax machine will disconnect immediately if there is any delay in receiving the data.

Unfortunately, a typical packet-switched network, such as the Internet, does not possess the deterministic attributes that are needed by fax machines. Due to the undeterministic nature of IP networks, the speed of access link and traffic condition are often unpredictable. This creates a technical challenge to implement real-time faxing through the Internet.

FaxTop™ employs a proprietary algorithm called Network Congestion Control, which enables FaxTop™ to provide reliable fax transmission even under congested Internet traffic condition. It mainly consists of two parts:

1. Intelligent Buffering

   With a special adaptive data buffering algorithm, it synchronizes the transmission speeds between the on-ramp and off-ramp FaxTop™ s. This is to ensure that the sending fax machine does not go faster than the receiving side and results in waiting for it to complete. It also prevents the situation where the off-ramp FaxTop™ goes too fast and has nothing to send to the receiving fax machine. This is important because once the data stream is released to the receiving fax machine, it can not be interrupted, otherwise connection will be dropped.

2. Timeout Extender

   At various points during a fax transmission, timing is particularly sensitive and the fax machine is very vulnerable to timeout. At these critical stages, if the Internet traffic is slow and data can not arrive in time, FaxTop™ will keep sending "dummy" data to the fax machine to keep the connection alive. As a result, FaxTop™ is able to extend these timeouts to a level that is suitable for Internet, even when the net is congested.

Remote Ring Wakeup

A lot of companies can not afford a dedicated/leased line connection to the Internet. The Dialup version (FT120D) of FaxTop™ is built with these companies in mind. It requires a telephone line and a regular PPP dialup account. Users only need to configure the login parameters (eg. user id and password) once during installation. FaxTop™ will automatically dial in to the ISP when the user tries to send a fax, and log off once the transmission is done.

If the off-ramp FaxTop™ is a FT120D, the on-ramp FaxTop™ will need to notify the off-ramp side to log on to the Internet before the two FaxTop™ can establish a connection. This is accomplished by the Remote Ring Wakeup feature. The on-ramp FaxTop™ will make a telephone call to the off-ramp side. The phone call serves as a "wakeup" notification to the off-ramp FaxTop™. The off-ramp FaxTop™ will then know to log on to the Internet so that a fax can be sent to it. It is important to note that the notification only consists of a few seconds of ringing, the off-ramp FaxTop™ does not actually answer the call. Therefore, there will not be any toll charges incurred for the ring wakeup call.

IP Address Resolution

FaxTop™ uses a direct point-to-point IP connection to transfer data from the sending fax machine to the receiving one. During a fax transmission, the on-ramp FaxTop™ communicates directly with the off-ramp FaxTop™, there is no other server or gateway needed to complete the transaction.

When the on-ramp FaxTop™ initiates a fax transmission, it has to know the off-ramp FaxTop™'s IP address in order to establish a connection with it. The IP address is readily available if the off-ramp FaxTop™ is an Ethernet version, since it will have a static IP. However, if the off-ramp FaxTop™ is a Dialup version, the IP address is not known until it is logged on to the Internet (which is triggered by the Ring Wakeup from the on-ramp FaxTop™). Once the off-ramp FaxTop™ obtains its IP address, it will post it to the LDAP directory server specified in the configuration. The on-ramp FaxTop™ will then find the IP by searching the LDAP server.

FaxTop™ is compatible with any directory server that provides LDAP V2.0 interface, eg. Microsoft Internet Locater Server (ILS).

Secure Transmission

Email based Internet faxing products/services first store the fax as a file (usually in TIFF format), then forward it on to a remote gateway. The gateway will convert the file back to fax data and send it out to the receiving fax machine. This creates a security risk since the file can potentially be intercepted and viewed by hackers.

Since FaxTop™ uses a point-to-point connection to accomplish real-time Internet fax transmission, there is no intermediate file involved. The on-ramp FaxTop™ packetizes the raw fax data, pass them over to the off-ramp FaxTop™. The off-ramp FaxTop™ formats the incoming packets back to raw fax data and prints it out on the receiving fax machine. With the combination of point-to-point connection and proprietary packetization scheme, FaxTop™ provides a very secure real-time Internet faxing solution.

Fax Transmission Process Flow

This section shows the step by step process that a FaxTop™ goes through during a fax transmission.

Ethernet to Ethernet (FT120E to FT120E)

On-ramp FaxTop™ (FT120E)	Off-ramp FaxTop™ (FT120E)
User picks up the local fax machine's handset and enters the off-ramp FaxTop™ phone number	
Searches the internal phonebook and determines that the off-ramp FaxTop™ is an Ethernet version (ie. Static IP)	
Tries to establish connection with the off-ramp FaxTop™	Receives connection request from the on-ramp FaxTop™
	Accepts connection request and rings the local fax machine
	Local fax machine goes into receive mode
Notifies the user to press the "START" button on the local fax machine	Notifies the on-ramp FaxTop™ that it is now ready to receive fax data
Packetizes the raw data from the local fax machine and sends them over to the off-ramp FaxTop™	Receives data packets, reformats them to raw fax data and sends it out to the local fax machine
	Local fax machine confirms all pages are received
Passes confirmation on to the local fax machine	Sends confirmation to the on-ramp FaxTop™
Local fax machine hangs up	Local fax machine hangs up

Dialup to Ethernet (FT120D to FT120E)

On-ramp FaxTop™ (FT120D)	Off-ramp FaxTop™ (FT120E)
User picks up the local fax machine's handset and enters the off-ramp FaxTop™ phone number	
Searches the internal phonebook and determines that the off-ramp FaxTop™ is an Ethernet version (ie. Static IP)	
Dials up to the ISP and logs on to the Internet	
Tries to establish connection with the off-ramp FaxTop™	Receives connection request from the on-ramp FaxTop™
	Accepts connection request and rings the local fax machine
	Local fax machine goes into receive mode
Notifies the user to press the "START" button on the local fax machine	Notifies the on-ramp FaxTop™ that it is now ready to receive fax data
Packetizes the raw data from the local fax machine and sends them over to the off-ramp FaxTop™	Receives data packets, reformats them to raw fax data and sends it out to the local fax machine
	Local fax machine confirms all pages are received
Passes confirmation on to the local fax machine	Sends confirmation to the on-ramp FaxTop™
Local fax machine hangs up	Local fax machine hangs up
Disconnects from the ISP	

Ethernet to Dialup (FT120E to FT120D)

On-ramp FaxTop™ (FT120E)	Off-ramp FaxTop™ (FT120D)
User picks up the local fax machine's handset and enters the off-ramp FaxTop™ phone number	

On-ramp FaxTop™ (FT120E)	Off-ramp FaxTop™ (FT120D)
Searches the internal phonebook and determines that the off-ramp FaxTop™ is a Dialup version (ie. Dynamic IP)	
Issues a Remote Ring Wakeup call to the off-ramp FaxTop™	Receives Ring Wakeup
Keeps polling the directory server to find the off-ramp FaxTop™ 's IP address	Dials up to the ISP and logs on to the Internet
Finds the off-ramp FaxTop™ 's IP address	Registers its IP address with the LDAP directory server
Tries to establish connection with the off-ramp FaxTop™	Receives connection request from the on-ramp FaxTop™
	Accepts connection request and rings the local fax machine
	Local fax machine goes into receive mode
Notifies the user to press the "START" button on the local fax machine	Notifies the on-ramp FaxTop™ that it is now ready to receive fax data
Packetizes the raw data from the local fax machine and sends them over to the off-ramp FaxTop™	Receives data packets, reformats them to raw fax data and sends it out to the local fax machine
	Local fax machine confirms all pages are received
Passes confirmation on to the local fax machine Local fax machine hangs up	Sends confirmation to the on-ramp FaxTop™ Local fax machine hangs up
	De-registers its IP address Disconnects from the ISP

Dialup to Dialup (FT120D to FT120D)

On-ramp FaxTop™ (FT120D)	Off-ramp FaxTop™ (FT120D)
User picks up the local fax machine's handset and enters the off-ramp FaxTop™ phone number	
Searches the internal phonebook and determines that the off-ramp FaxTop™ is a Dialup version (ie. Dynamic IP)	
Dials up to the ISP and logs on to the Internet	
Issues a Remote Ring Wakeup call to the off-ramp FaxTop™	Receives Ring Wakeup
Keeps polling the directory server to find the off-ramp FaxTop™ 's IP address	Dials up to the ISP and logs on to the Internet
Finds the off-ramp FaxTop™ 's IP address	Registers its IP address with the LDAP directory server
Tries to establish connection with the off-ramp FaxTop™	Receives connection request from the on-ramp FaxTop™
	Accepts connection request and rings the local fax machine
	Local fax machine goes into receive mode
Notifies the user to press the "START" button on the local fax machine	Notifies the on-ramp FaxTop™ that it is now ready to receive fax data
Packetizes the raw data from the local fax machine and sends them over to the off-ramp FaxTop™	Receives data packets, reformats them to raw fax data and sends it out to the local fax machine
	Local fax machine confirms all pages are received
Passes confirmation on to the local fax machine Local fax machine hangs up	Sends confirmation to the on-ramp FaxTop™ Local fax machine hangs up
Disconnects from the ISP	De-registers its IP address Disconnects from the ISP

Conclusion

FaxTop™ is a "thin-client" solution that allows standalone fax machines to communicate in an IP based data network environment. It provides secure and reliable real-time Internet fax transmission between two facsimile machines. From the user's point of view, the FaxTop™ is virtually transparent, fax machine's operation remains the same --- enters the receiver's phone number, waits for the receiving fax machine to answer the call, then presses the "START" button to begin the transmission. With the innovative Remote Ring Wakeup and IP Address Resolution features, both the on-ramp and off-ramp FaxTop™ can be a Dialup version. Dialup-to-Dialup combination is ideal for companies who can not afford a dedication Internet connection.

Companies can use FaxTop™ to Internet enable their existing fax machines, fax transmission will then be carried out over the much more economical IP data network. As a result, companies will realize substantial savings in their telecommunication cost.

Other Relevant Info

- Cost comparison chart between PSTN and FaxTop   transmission

- Benefit (and distinction) of real-time vs. email Internet fax

- System Architecture (refer to Brooktrout's Boston White paper for example)

- Security and Encryption

- SDK for 3rd party developer

- Future development

- ITU/IETF T.37, T.38

- FAQ (Q&A)

* Look at "Containing the Costs of Fax Transmissions..." on the radlinx web
  site.

* Look at http://China.si.umich.edu/telecom/technical-info.html