Volume

4

MANAGING CALL FLOWS USING H.323

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Executive Summary

This is the fourth of six technical briefing papers that examine the concepts, operation and analysis of *converged networks*. A converged network — one that combines voice, data, and other signal transmissions into a single, higher-speed network interface — is more complex than a single-purpose voice or data network. Specific protocols have been developed to manage the call establishment and disconnect procedures. Those procedures are known as *signaling*, and the protocols described in this paper have been defined by the International Telecommunication Union — Telecommunication Standards Sector (ITU-T), in ITU-T Recommendation H.323.

H.323-based networks include four elements: Terminals, Gateways, Gatekeepers and Multipoint Control Units. Terminals interface with the end users and provide for real-time, two-way communication with another Terminal, Gateway or Multipoint Control Unit. Gateways provide the physical and logical connections from the packet-switched networks to and from the circuit-switched networks. Gatekeepers, which are optional for simple networks, provide network management functions, including bandwidth control and address translation. Multipoint Control Units allow three or more Terminals or Gateways to participate in a multiparty conference.

The H.323 protocol suite is an umbrella standard that includes functions provided by other ITU-T and Internet Engineering Task Force (IETF) standards. The first, ITU-T H.225.0, provides call setup/disconnect and Terminal to Gatekeeper signaling. The ITU-T H.245 protocol adds terminal control functions that are used to negotiate terminal capabilities, channel usage, and other end-to-end functions. The IETF Real-Time Transport Protocol (RTP) and Real-Time Control Protocol (RTCP) provide information transport and session management. Finally, ITU-T standard voice and video encoding algorithms provide the analog-to-digital conversions and signal compression required for bandwidth optimization.

A case study, showing two Microsoft® Windows® workstations running the NetMeeting® application, will illustrate the operation and analysis of these protocols.

1. H.323 Architecture

The ITU-T H.323 recommendation is a standard for the transmission of multimedia signals (voice and data) over local area networks (LANs) that provide a nonguaranteed quality of service, such as Ethernet. This architecture includes several key components, all of which must cooperate to assure successful end-to-end communication:

- Terminals (clients): provide for real-time, two-way communication with another Terminal, Gateway or Multipoint Control Unit.
- Gateways (GW): provide physical and logical connections from the packet-switched networks to and from the circuit-switched networks.
- Gatekeepers (GK): are optional within H.323 networks, and when present, provide network management functions, including address translation, admissions control and bandwidth control.
- Multipoint Control Units (MCU): allow three or more Terminals and Gateways to participate in a multipoint conference.

The various H.323 components are illustrated in Figure 1.

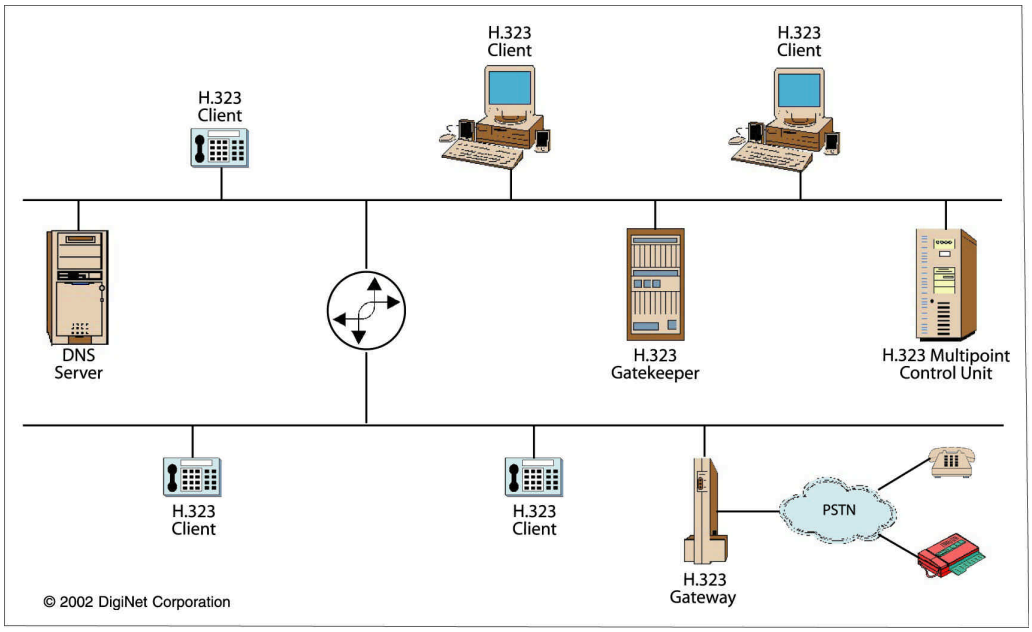

FIGURE 1. **H.323 Components and Architecture**

2. H.323-related Protocols

H.323 incorporates elements from several other ITU-T and IETF standards:

- ITU-T H.225.0: Call signaling and Terminal to Gatekeeper signaling functions, both derived from another ITU-T standard, Q.931. Terminal to Gatekeeper signaling is known as Registration, Admission, and Status (RAS) signaling. These signaling functions initiate and terminate calls between end stations.
- ITU-T H.245: Terminal control functions that are used to negotiate terminal capabilities, channel usage, and related parameters. These procedures allow the end stations to exchange audio, video, and data capabilities, request transmission in a particular mode, and other terminal-to-terminal functions.
- IETF Real-Time Transport Protocol (RTP) and Real-Time Control Protocol (RTCP) provide information transport and session management. RTP is the protocol within the H.323 suite that carries the digitally-encoded voice or video packets between the end stations. RTCP manages the sessions by periodically transmitting packets containing feedback on the quality of the data distribution.
- ITU-T recommended encoding algorithms, such as G.723.1, G.728 and G.729 for audio encoding, or H.261 or H.263 for video encoding.

Note that the Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) are used in support of these protocols, as shown in Figure 2.

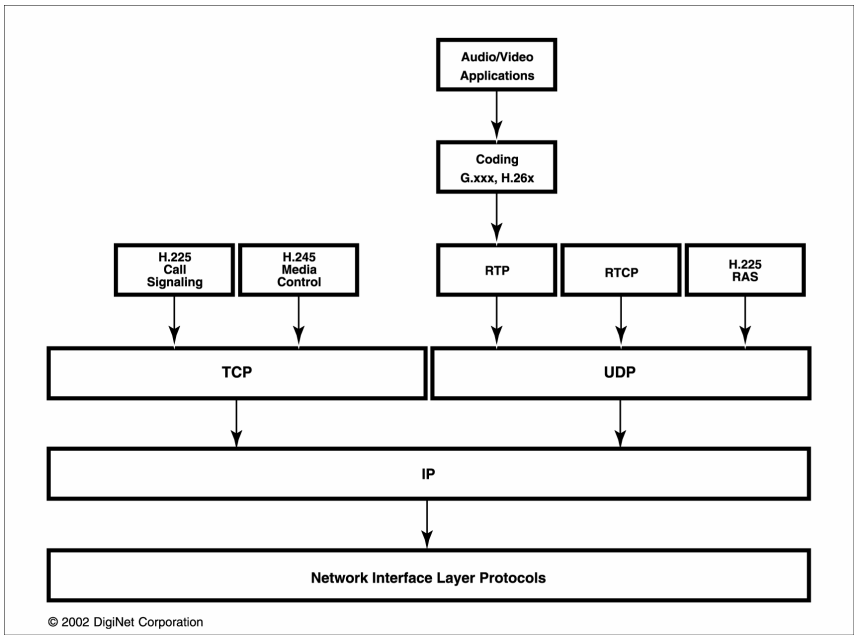

FIGURE 2. **H.323-related Protocols**

3. Case Study: Analyzing Microsoft NetMeeting Connections

As seen in the two previous sections, analyzing voice and/or video over IP sessions is more complicated than most LAN or WAN applications because of the larger number of protocols involved. As an example of this analysis, consider the simple network consisting of two workstations running Microsoft Corporations's *NetMeeting* application, shown in Figure 3. In this scenario, NetMeeting Station 200 initiates a call to NetMeeting Station 201, initiating the protocol interactions we will study.

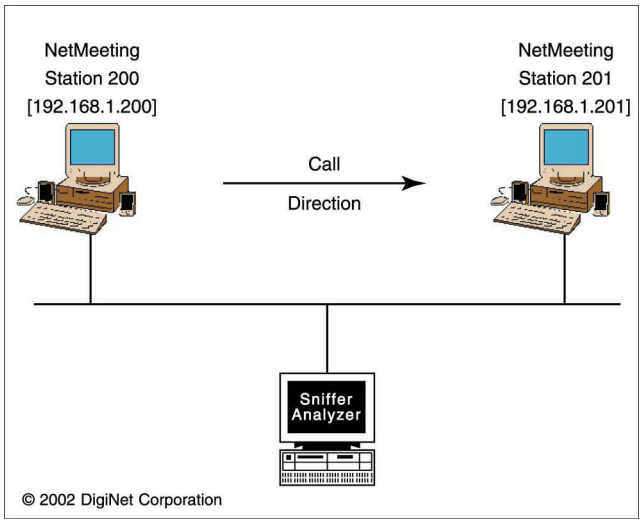

FIGURE 3. **H.323 NetMeeting-to-NetMeeting Topology**

The protocol operations for these workstations follow a sequence of four functions that are found with most voice and data communication processes. These functions are detailed in Figure 4A and include the direction of the information flow:

1. Connection establishment using TCP and H.225 (frames 4-12)
2. Parameter exchange using TCP and H.245 (frames 13-36).
3. Information transfer using RTP and RTCP (frames 64-819).
4. Connection termination using H.245, H.225, and TCP (frames 835-844).

For brevity, some of the RTP voice traffic (frames 64-819) has been filtered out, and is not shown in either Figure 4A or the accompanying Trace 1.

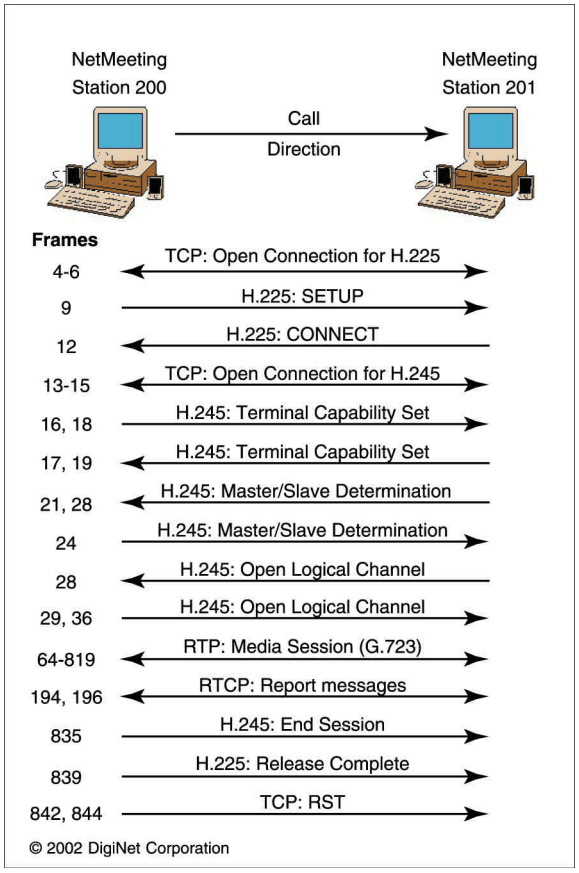

FIGURE 4A. **H.323 NetMeeting-to-NetMeeting Connection Protocol Sequence**

The details of these four functions are shown in Trace 1, provided by output from the Network Associates, Inc. *Sniffer* ® analyzer. Note that Trace 1 provides four columns of information: the Frame Number, the Source Station, the Destination Station, and a brief Summary of the protocol operations within that frame. Frames of special interest, that will be discussed further, are shown in bold face type. For brevity, traffic not relevant to our discussion has been filtered out, yielding some gaps in frame numbers.

TRACE 1. **H.323 NetMeeting-to-NetMeeting Connection Protocol Summary**

```
Frame  Source          Destination     Summary

  4    NetMeeting 200  NetMeeting 201  TCP D=1720 S=1349 SYN SEQ=32695659
  5    NetMeeting 201  NetMeeting 200  TCP D=1349 S=1720 SYN ACK=32695660
                                           SEQ=12362163 LEN=0 WIN=8760
```

```
 6    NetMeeting 200   NetMeeting 201   TCP D=1720 S=1349 ACK=12362164
                                            WIN=8760
 7    NetMeeting 200   NetMeeting 201   H225 Length = 239
 8    NetMeeting 201   NetMeeting 200   TCP D=1349 S=1720 ACK=32695664
                                            WIN=8756
 9    NetMeeting 200   NetMeeting 201   H225 Setup (User-User)
                                            CallRefValue=25730 (Signaling)
10    NetMeeting 201   NetMeeting 200   H225 Length = 114
11    NetMeeting 200   NetMeeting 201   TCP D=1720 S=1349 ACK=12362168
                                            WIN=8756
12    NetMeeting 201   NetMeeting 200   H225 Connect (User-User)
                                            CallRefValue=25730 (Signaling)
13    NetMeeting 200   NetMeeting 201   TCP D=1062 S=1350 SYN SEQ=32695668
                                            LEN=0 WIN=8192
14    NetMeeting 201   NetMeeting 200   TCP D=1350 S=1062 SYN ACK=32695669
                                            SEQ=12362452 LEN=0 WIN=8760
15    NetMeeting 200   NetMeeting 201   TCP D=1062 S=1350 ACK=12362453
                                            WIN=8760
16    NetMeeting 200   NetMeeting 201   H245 Req: Terminal Capability Set,
                                            Req: Master Slave Determination
17    NetMeeting 201   NetMeeting 200   H245 Req: Terminal Capability Set
18    NetMeeting 200   NetMeeting 201   H245 Continuation of frame 16;
                                            529 Bytes of data
19    NetMeeting 201   NetMeeting 200   H245 Continuation of frame 17;
                                            518 Bytes of data
20    NetMeeting 200   NetMeeting 201   H245 Res: Terminal Capability Set Ack
21    NetMeeting 201   NetMeeting 200   H245 Req: Master Slave Determination
22    NetMeeting 200   NetMeeting 201   H245 Continuation of frame 20;
                                            3 Bytes of data
23    NetMeeting 201   NetMeeting 200   H245 Res: Terminal Capability Set Ack
24    NetMeeting 200   NetMeeting 201   H245 Res: Master Slave Determination
                                            Ack
25    NetMeeting 201   NetMeeting 200   H245 Continuation of frame 23;
                                            3 Bytes of data
26    NetMeeting 200   NetMeeting 201   TCP D=1062 S=1350 ACK=12362993
                                            WIN=8220
27    NetMeeting 200   NetMeeting 201   TCP D=1720 S=1349 ACK=12362278
                                            WIN=8646
28    NetMeeting 201   NetMeeting 200   H245 Res: Master Slave Determination
                                            Ack, Req: Open Logical Channel,
                                            Req: Open Logical Channel
29    NetMeeting 200   NetMeeting 201   H245 Req: Open Logical Channel,
                                            Req: Open Logical Channel,
                                            Res: Open Logical Channel Ack,
                                            Res: Open Logical Channel Ack
30    NetMeeting 200   NetMeeting 201   TCP D=1503 S=1351 SYN SEQ=32695671
                                            LEN=0 WIN=8192
31    NetMeeting 201   NetMeeting 200   TCP D=1351 S=1503 SYN ACK=32695672
                                            SEQ=12362785 LEN=0 WIN=8760
32    NetMeeting 200   NetMeeting 201   TCP D=1503 S=1351 ACK=12362786
                                            WIN=8760
33    NetMeeting 200   NetMeeting 201   TCP D=1503 S=1351 ACK=12362786
                                            SEQ=32695672 LEN=25 WIN=8760
34    NetMeeting 201   NetMeeting 200   TCP D=1351 S=1503 ACK=32695697
                                            SEQ=12362786 LEN=21 WIN=8735
35    NetMeeting 201   NetMeeting 200   TCP D=1350 S=1062 ACK=32696219
                                            WIN=8210
36    NetMeeting 200   NetMeeting 201   H245 Continuation of frame 29;
                                            95 Bytes of data
 .
 .
 .
190    NetMeeting 200   NetMeeting 201   RTP Payload=G.723 audio SEQ=33167
                                            SSRC=2072341204
191    NetMeeting 200   NetMeeting 201   RTP Payload=G.723 audio SEQ=33168
                                            SSRC=2072341204
```

```
192    NetMeeting 200   NetMeeting 201   RTP Payload=G.723 audio SEQ=33169
                                             SSRC=2072341204
193    NetMeeting 200   NetMeeting 201   RTP Payload=G.723 audio SEQ=33170
                                             SSRC=2072341204
194    NetMeeting 201   NetMeeting 200   RTCP Receiver Report PacketLost=0
                                             Jitter=36 Delay=0(sec)
195    CogentA8381F     Broadcast        DHCP Request, Message type: DHCP
                                             Discover
196    NetMeeting 200   NetMeeting 201   RTCP Sender Report
197    NetMeeting 200   NetMeeting 201   RTP Payload=G.723 audio SEQ=33171
                                             SSRC=2072341204
198    NetMeeting 200   NetMeeting 201   RTP Payload=G.723 audio SEQ=33172
                                             SSRC=2072341204
199    NetMeeting 200   NetMeeting 201   RTP Payload=G.723 audio SEQ=33173
                                             SSRC=2072341204
200    NetMeeting 200   NetMeeting 201   RTP Payload=G.723 audio SEQ=33174
                                             SSRC=2072341204
 .
 .
 .
835    NetMeeting 200   NetMeeting 201  Expert: Window FrozenH245
                                             Com: End Session Command
836    NetMeeting 200   NetMeeting 201  H245 Continuation of frame 835;
                                             2 Bytes of data
837    NetMeeting 201   NetMeeting 200  TCP D=1350 S=1062 ACK=32696321
                                             WIN=8109
838    NetMeeting 200   NetMeeting 201  Expert: Window FrozenH225 Length = 47
839    NetMeeting 200   NetMeeting 201  H225 ReleaseComplete (User-User)
                                             CallRefValue=25730 (Signaling)
840    NetMeeting 201   NetMeeting 200  TCP D=1349 S=1720 ACK=32695947
                                             WIN=8474
841    NetMeeting 201   NetMeeting 200  H225 Length = 47
842    NetMeeting 200   NetMeeting 201  TCP D=1720 S=1349 RST WIN=0
843    NetMeeting 201   NetMeeting 200  H245 Length=6
844    NetMeeting 200   NetMeeting 201  TCP D=1062 S=1350 RST WIN=0
```

Trace 2 illustrates another *Sniffer* display format, the *Detail* display, which provides detailed information regarding each field and subfield within a particular packet. This trace shows Frame 9, the H.225 SETUP message sent from Station 200 to Station 201. Many parameters are passed in this SETUP message. For example, the Protocol ID {0.0.8.2250.0.2} identifies the version of H.225 supported (version 2). A number of one-bit flags indicate the presence of a Terminal (with no Gatekeepers, Gateways, or MCUs present). The Manufacture Code, Product ID and Version ID (Microsoft NetMeeting, version 3.0) are also noted. The Call Type (Point-to-Point) is used to determine the bandwidth needed for this call. The last parameter, the GloballyUniqueID (Guid = 2DF9BA1C63D8D51190CA000065192D67), in the Setup-extension of the trace, is used to associate all RAS and signaling messages related to the same call. Many other parameters are included in the SETUP message, which are detailed in the H.225.0 standard. Those mentioned above are shown in bold face type.

TRACE 2. **H.225 SETUP Message Details**

```
- - - - - - - - - - - - - - - - - - - - Frame 9 - - - - - - - - - - - - - - - - - - - -

H225 ----- H.225 Call Signaling -----
     H225:
     H225:Protocol discriminator   = 8
     H225: Length of call reference = 2
     H225: Call reference field = 6482
     H225:  0... ....  .... .... = Message from originator
     H225:  .110 0100  1000 0010 =  = 25730 (Call reference value)
     H225: Message type = 5 (Setup)
     H225:
     H225: Information element identifier   = 0x4 (Bearer capability)
     H225: Length of information element = 3
     H225: Coding and capability flags = 88
     H225:                1... .... = Extension value(s) present
     H225:                .00. .... = Coding standard = 0 (CCITT standardized  coding)
     H225:                ...0 1000 = Information transfer capability = 8 (Unrestricted digital information)
     H225: Mode and rate flags = C0
     H225:          1... .... = Extension value(s) present
     H225:          .10. .... = Transfer mode = 2 (Packet mode)
     H225:          ...0 0000 = Information transfer rate = 0 (Used for packet mode calls)
     H225: Layer 1 protocol flag = A5
     H225:           1... .... = Extension value(s) present
     H225:           .01. .... = Layer 1 identification = 1
     H225:           ...0 0101 = Layer 1 protocol = 5 (H.221 and H.242)
     H225:
     H225: Information element identifier   = 0x28 (Display)
     H225: Display length = 17
     H225: Display = net-meeting-1 Qa<00>
     H225:
H225:
     H225: ----User-User Information----
     H225:
     H225: Information element identifier = 0x7E (User-User)
     H225: Length of user-user content = 203
     H225: Protocol discriminator = 5 (X.680 / X.691(PER)(ASN.1))
     H225:
     H225: Flags     = 10
     H225: 0... .... = No extension values present in H323-UserInformation
     H225: .0.. .... = user-data is not present
     H225: ..0. .... = No extension values present in h323-uu-pdu
     H225: ...1 .... = nonStandardData is present
     H225: .... 0... = No extension values present in h323-message-body
     H225: h323-message = 0 (Setup)
     H225:
     H225: Flags     = A8
     H225: 1... .... = Extension value(s) present in Setup
     H225: .0.. .... = h245Address is not present
     H225: ..1. .... = sourceAddress is present
     H225: ...0 .... = destinationAddress is not present
     H225: .... 1... = destCallSignalAddress is present
     H225: .... .0.. = destExtraCallInfo is not present
     H225: .... ..0. = destExtraCRV is not present
     H225: .... ...0 = callServices is not present
     H225:
     H225: Protocol Id = {0.0.8.2250.0.2}
     H225: H225.0 version = 2
     H225:
     H225: Number of (sourceAddress) = 1
     H225:
     H225: Flags     = 40
     H225: 0... .... = No extension value(s) present in AliasAddress
     H225: AliasAddress = 1 (H323-ID)
     H225: H323-ID = "net-meeting-1 Qa"
     H225:
```

H225: **Flags = 22**
H225: **0... .... = No extension value(s) present in EndpointType**
H225: **.0.. .... = nonStandardData is not present**
H225: **..1. .... = Vendor is present**
H225: **...0 .... = Gatekeeper is not present**
H225: **.... 0... = Gateway is not present**
H225: **.... .0.. = MCU is not present**
H225: **.... ..1. = Terminal is present**
H225:
H225: ....0 = No extension value(s) present in vendorIdentifier
H225: Flags = C0
H225: 1... .... = Product Id is present
H225: .1.. .... = Version Id is present
H225:
H225: ..0. .... = No extension value(s) present in H221NonStandard
H225: T.35 country code = 0xB5 (USA)
H225: T.35 extension = 0
H225: **Manufacture code = 0x534C (Microsoft)**
H225: **Product Id = Microsoft<AE> NetMeeting<AE00>**
H225: **Version Id = 3.0<00>**
H225:
H225: Flags = 00
H225: 0... .... = No extension value(s) present in terminal
H225: .0.. .... = nonStandardData is not present
H225: ..0. .... = MC is OFF
H225: ...0 .... = Undefined node is OFF
H225:
H225: destCallSignalAddress
H225:
H225: .... 0... = No extension value(s) present in TransportAddress
H225: TransportAddress = 0 (IP address)
H225:
H225: IP = 192.168.1.201
H225: Port = 1720
H225:
H225: Flags = 00
H225: 0... .... = Active MC is OFF
H225:
H225: Conference Id = 2EF9BA1C63D8D51190CA000065192D67
H225:
H225: Flags = 00
H225: 0... .... = No extension value(s) present in conferenceGoal
H225: Conference goal = 0 (Create)
H225:
H225: callType
H225:
H225: ...0 .... = No extension value(s) present in callType
H225: **callType = 0 (Point to point)**
H225:
H225: * Setup - extension *
H225: .... ..0. = Extension length determinant
H225: Number of extensions = 9
H225: .... .1.. = sourceCallSignalAddress is present
H225: .... ..0. = remoteExtensionAddress is not present
H225: ....1 = callIdentifier is present
H225: Flags = 0C
H225: 0... .... = h245SecurityCapability is not present
H225: .0.. .... = tokens is not present
H225: ..0. .... = cryptoTokens is not present
H225: ...0 .... = fastStart is not present
H225: .... 1... = mediaWaitForConnect is present
H225: .... .1.. = canOverlapSend is present
H225:
H225: Flags = 00
H225: 0... .... = No extension value(s) present in sourceCallSignalAddress
H225: sourceCallSignalAddress = 0 (IP address)
H225:
H225: IP = 192.168.1.200

```
H225: Port = 1349
H225:
H225: Flags     = 00
H225: 0... .... = No extension value(s) present in callIdentifier
H225: Guid = 2DF9BA1C63D8D51190CA000065192D67
H225:
H225: Flags     = 00
H225: 0... .... = Media wait for connect is OFF
H225: Flags     = 00
H225: 0... .... = Can overlap send is OFF
H225:
H225: Flags     = 40
H225: 0... .... = No extension value(s) present in NonStandardIdentifier
H225: nonStandardIdentifier = 1 (H221 non standard)
H225:
H225: ..0. .... = No extension value(s) present in H221NonStandard
H225: T.35 country code = 0xB5 (USA)
H225: T.35 extension    = 0
```

In Frame 16, Station 200 negotiates transmission parameters by sending an H.245 Terminal Capability Set message to Station 201 (Trace 3). This includes a Protocol ID {0.0.8.245.0.3}, and the Maximum Audio Delay Jitter (60 milliseconds). Next come Capability Parameters and Tables, including Receive Multipoint Capability, Transmit Multipoint Capability, Receive and Transmit Multipoint Capability, Multipoint Controller (MC) Capability, Media Packetization Capability, and the Capability Table. Details regarding these parameters are found in the H.245 standard.

TRACE 3. **H.245 Request Terminal Capabilities Set Message Details**

```
- - - - - - - - - - - - - - - - - - - - Frame 16 - - - - - - - - - - - - - - - - - - - -

H245:  Vector  Offset   Length    Frame
    H245: ----------------------------------
    H245:        0  0x0036        4       16
    H245:        1  0x0036      529       18
    H245: ----------------------------------
    H245: 533 bytes of re-assembled data.
    H245:
    H245: ----- Control Protocol for Multimedia Communication -----
    H245:
    H245: Message length = 522
    H245: Flags     = 02
    H245: 0... .... = No extension value(s) present in H.245 control message
    H245: H.245 call control message type = 0 (Request)
    H245:
    H245: ...0 .... = No extension value(s) present in request
    H245: Request type = 2 (Terminal Capability Set)
    H245:
    H245: Flags     = 70
    H245: 0... .... = No extension value(s) present in terminalCapabilitySet
    H245: .1.. .... = multiplexCapability is present
    H245: ..1. .... = capabilityTable is present
    H245: ...1 .... = capabilityDescriptors is present
    H245: Sequence number = 1
    H245: Protocol Id = {0.0.8.245.0.3}
    H245:
    H245: Flags     = 80
    H245: 1... .... = Extension value(s) present in MultiplexCapability
```

H245: .0.. .... = Choice value is 6 bits long
H245: Multiplex capability = 0 (H2250 Capability)
H245: Flags = 00
H245: 0... .... = No extension value(s) present in h2250Capability
H245: **Maximum audio delay jitter = 60 (ms)**
H245:
H245: ***** Receive Multipoint Capability *****
H245:
H245: Flags = 00
H245: 0... .... = No extension value(s) present in receive multipoint capability
H245: .0.. .... = Multicast capability is OFF
H245: ..0. .... = Multi unicast conference is OFF
H245:
H245: Media Distribution Capability #1
H245: Flags = 00
H245: 0... .... = No extension value(s) present in mediaDistributionCapability
H245: .0.. .... = centralizedData is not present
H245: ..0. .... = distributedData is not present
H245: ...0 .... = Centralized control is OFF
H245: .... 0... = Distributed control is OFF
H245: .... .0.. = Centralized audio is OFF
H245: .... ..0. = Distributed audio is OFF
H245: ....0 = Centralized video is OFF
H245: Flags = 00
H245: 0... .... = Distributed video is OFF
H245:
H245: ***** Transmit Multipoint Capability *****
H245:
H245: .0.. .... = No extension value(s) present in transmit multipoint capability
H245: ..0. .... = Multicast capability is OFF
H245: ...0 .... = Multi unicast conference is OFF
H245:
H245: Media Distribution Capability #1
H245: Flags = 00
H245: 0... .... = No extension value(s) present in mediaDistributionCapability
H245: .0.. .... = centralizedData is not present
H245: ..0. .... = distributedData is not present
H245: ...0 .... = Centralized control is OFF
H245: .... 0... = Distributed control is OFF
H245: .... .0.. = Centralized audio is OFF
H245: .... ..0. = Distributed audio is OFF
H245: ....0 = Centralized video is OFF
H245: Flags = 00
H245: 0... .... = Distributed video is OFF
H245:
H245: ***** Receive and Transmit Multipoint Capability *****
H245:
H245: .0.. .... = No extension value(s) present in receive and transmit multipoint: capability
H245: ..0. .... = Multicast capability is OFF
H245: ...0 .... = Multi unicast conference is OFF
H245:
H245: Media Distribution Capability #1
H245: Flags = 00
H245: 0... .... = No extension value(s) present in mediaDistributionCapability
H245: .0.. .... = centralizedData is not present
H245: ..0. .... = distributedData is not present
H245: ...0 .... = Centralized control is OFF
H245: .... 0... = Distributed control is OFF
H245: .... .0.. = Centralized audio is OFF
H245: .... ..0. = Distributed audio is OFF
H245: ....0 = Centralized video is OFF
H245: Flags = 00
H245: 0... .... = Distributed video is OFF
H245:
H245: ***** MC Capability *****
H245:
H245: .0.. .... = No extension value(s) present in mcCapability
H245: ..0. .... = Centralized Conference MC is OFF

H245: ...0 .... = Decentralized Conference MC is OFF
H245:
H245: .... 0... = RTCP video control capability is OFF
H245:
H245: ***** Media Packetization Capability *****
H245:
H245: .... .0.. = No extension value(s) present in MediaPacketizationCapability
H245: .... ..0. = H261A video packetization is OFF
H245:
H245: ***** Capability Table *****
H245:
H245: Number of capability table entry = 15
H245:
H245: Capability Table Entry Set #1
H245: Flags = 80
H245: 1... .... = capability is present
H245: Capability table entry number = 32768
H245: Flags = 04
H245: 0... .... = No extension value(s) present in Capability
H245: Capability = 0 (Non standard)
H245: nonStandardIdentifier = 1 (H221 Non Standard)
H245: T.35 country code = 0xB5 (USA)
H245: T.35 extension = 66
H245: Manufacture code = 0x8080 (Intel)
H245: Data: 1 byte(s) of data
H245:
H245: Capability Table Entry Set #2
H245: Flags = 80
H245: 1... .... = capability is present
H245: Capability table entry number = 15
H245: Flags = 48
H245: 0... .... = No extension value(s) present in Capability
H245: Capability = 9 (Receive and transmit data application capability)
H245: .... .0.. = No extension value(s) present in dataApplicationCapability
H245: .... ..0. = No extension value(s) present in application
H245: Application = 1 (T120)
H245: ...1 .... = Extension value(s) present in DataProtocolCapability
H245: .... 0... = Extension index format
H245: Data protocol capability = 3 (Separate LAN stack)
H245: Maximum bit rate = 825000 (100 bit/s)
H245:
H245: Capability Table Entry Set #3
H245: Flags = 80
H245: 1... .... = capability is present
H245: Capability table entry number = 1
H245: Flags = 20
H245: 0... .... = No extension value(s) present in Capability
H245: Capability = 4 (Receive audio capability)
H245: .... .0.. = No extension value(s) present in AudioCapability
H245: Audio capability = 0 (Non standard)
H245: nonStandardIdentifier = 1 (H221 Non Standard)
H245: T.35 country code = 0xB5 (USA)
H245: T.35 extension = 0
H245: Manufacture code = 0x534C (Microsoft)

After the terminal parameters are established, RTP packets carry voice information (Trace 4). Frame 64 contains 24 octets (bytes) of G.723.1 encoded information , with a Sequence Number of 33129, and a Time Stamp of 4808 (601.000 milliseconds).

TRACE 4. **RTP Packet with G.723.1 Audio Payload Details**

```
- - - - - - - - - - - - - - - - - - - - Frame 64 - - - - - - - - - - - - - - - - - - - -

RTP: ----- Real-Time Transport Protocol -----
     RTP:
     RTP: Ver, Pad, Ext, CC:        = 80
     RTP:                10.. .... = Version = 2 (RFC 1889)
     RTP:                ..0. .... = Padding = 0 (Zero bytes of Padding at the End)
     RTP:                ...0 .... = Header Extension Bit = 0,(No Header Extension after Fixed Header)
     RTP:                .... 0000 = Contributor Count = 0
     RTP: Marker, Payload Type: = 84
     RTP:           1... .... = Marker 1
     RTP:           .000 0100 = Payload Type 4 (G.723 audio)
     RTP: Sequence Number      = 33129
     RTP: Time Stamp           = 4808 (601.000 ms)
     RTP: SSRC                 = 2072341204
     RTP:
     RTP: ----- G.723: Dual Rate Speech Coder For Multimedia Communications Transmitting at 5.3 and 6.3 kbit/s
     RTP:
     RTP: [24 bytes of G.723 audio data]
     RTP:
```

Frame 194 (Trace 5) is an RTCP Receiver Report that includes a number of statistics, including the Cumulative Packets Lost (0) and Interarrival Jitter (36 milliseconds). Frame 196 is a Sender Report that details a Packet Count (42), Octet Count (1008), and other details. Both reports include Source Description information.

TRACE 5. **RTCP Packet Details**

```
- - - - - - - - - - - - - - - - - - - - Frame 194 - - - - - - - - - - - - - - - - - - - -

RTCP: ----- RTP Control Protocol -----
     RTCP:
     RTCP: Ver, Pad, RC:        = 81
     RTCP:           10.. .... = Version = 2 (RFC 1889)
     RTCP:           ..0. .... = Padding = 0
     RTCP:           ...0 0001 = Reception report count = 1
     RTCP: Packet type          = 201 (Receiver Report)
     RTCP: Length               = 8 (32-bit words)
     RTCP: SSRC of packet sender = 3687095248
     RTCP:
     RTCP: SSRC                      = 2072341204
     RTCP: Fraction lost             = 0.00000
     RTCP: Cumulative packets lost   = 0
     RTCP: Extended highest sequence #  = Cycle:0, Seq:33170
     RTCP: Interarrival jitter       = 36
     RTCP: Last SR timestamp         = 0
     RTCP: Delay since last SR       = 0 (Sec)
     RTCP:
     RTCP: ----- RTP Control Protocol -----
     RTCP:
     RTCP: Ver, Pad, RC:        = 81
     RTCP:           10.. .... = Version = 2 (RFC 1889)
     RTCP:           ..0. .... = Padding = 0
     RTCP:           ...0 0001 = Source count = 1
     RTCP: Packet type          = 202 (Source Description)
     RTCP: Length               = 8 (32-bit words)
     RTCP:
     RTCP: SSRC/CSRC            = 3687095248
     RTCP: SDES item       = 1 (CNAME)
```

```
     RTCP:   Length       = 10
     RTCP:   User/Domain   = "NETMEETING"
     RTCP: SDES item      = 2 (NAME)
     RTCP:   Length       = 8
     RTCP:   User/Domain   = "UserName"
     RTCP:

- - - - - - - - - - - - - - - - - - - - Frame 196 - - - - - - - - - - - - - - - - - - - -

RTCP: ----- RTP Control Protocol -----
     RTCP:
     RTCP: Ver, Pad, RC:         = 80
     RTCP:           10.. .... = Version = 2 (RFC 1889)
     RTCP:           ..0. .... = Padding = 0
     RTCP:           ...0 0000 = Reception report count = 0
     RTCP: Packet type          = 200 (Sender Report)
     RTCP: Length               = 7 (32-bit words)
     RTCP: SSRC of sender       = 2072341204
     RTCP:
     RTCP: NTP reference timestamp   = 1026395.42773 sec
     RTCP: RTP timestamp             = 23696
     RTCP: Sender's packet count     = 42
     RTCP: Sender's octet count      = 1008
     RTCP:
     RTCP: ----- RTP Control Protocol -----
     RTCP:
     RTCP: Ver, Pad, RC:         = 81
     RTCP:           10.. .... = Version = 2 (RFC 1889)
     RTCP:           ..0. .... = Padding = 0
     RTCP:           ...0 0001 = Source count = 1
     RTCP: Packet type          = 202 (Source Description)
     RTCP: Length               = 9 (32-bit words)
     RTCP:
     RTCP: SSRC/CSRC            = 2072341204
     RTCP: SDES item      = 1 (CNAME)
     RTCP:   Length       = 10
     RTCP:   User/Domain   = "NET-MEET-1"
     RTCP: SDES item      = 2 (NAME)
     RTCP:   Length       = 13
     RTCP:   User/Domain   = "Administrator"
     RTCP:
```

When the parties have completed their conversation, Station 200 hangs up, causing an H.245 End Session command to be transmitted (Trace 6).

TRACE 6. **H.245 End Session Command Message Details**

```
- - - - - - - - - - - - - - - - - - - - Frame 835 - - - - - - - - - - - - - - - - - - - -

H245:   Vector  Offset   Length    Frame
     H245: ----------------------------------
     H245:        0  0x0036        4      835
     H245:        1  0x0036        2      836
     H245: ----------------------------------
     H245: 6 bytes of re-assembled data.
     H245:
     H245: ----- Control Protocol for Multimedia Communication -----
     H245:
     H245: Message length = 6
     H245: Flags     = 4A
     H245: 0... .... = No extension value(s) present in H.245 control message
```

```
    H245: H.245 call control message type = 2 (Command)
    H245:
    H245: ...0 .... = No extension value(s) present in CommandMessage
    H245: Command = 5 (End Session Command)
    H245: .... ...0 = No extension value(s) present in EndSessionCommand
    H245: End session command = 1 (Disconnect)
```

The H.245 End Session command triggers a H.225 Release Complete message (sent by Station 200, and shown in Trace 7), followed by a TCP RESET (review Trace 1). Note that the GloballyUniqueID (Guid = 2DF9BA1C63D8D51190CA000065192D67) in the last line of the H.225.0 Release Complete message is the same value as the one shown in the H.225.0 Setup message (review Trace 2).

TRACE 7. **H.225 Release Complete Message Details**

```
- - - - - - - - - - - - - - - - - - - - Frame 839 - - - - - - - - - - - - - - - - - - -

H225: ----- H.225 Call Signaling -----
    H225:
    H225: Protocol discriminator   = 8
    H225: Length of call reference = 2
    H225: Call reference field = 6482
    H225:  0... ....  .... .... = Message from originator
    H225:  .110 0100  1000 0010 =  = 25730 (Call reference value)
    H225: Message type = 90 (Release Complete)
    H225:
    H225: Cause Information
    H225: Cause information element Id = 8
    H225: Cause contents length = 3
    H225: Coding standard and location flags = 00
    H225:                  0... .... = Continue
    H225:                  .00. .... = Coding standard = 0 (CCITT standardized coding)
    H225:                  .... 0000 = Location = 0 (User)
    H225: Recommendation flags = 00
    H225:          0... .... = Continue
    H225:          .000 0000 = Recommendation = 0 (Q.931)
    H225:
H225:
    H225: ----User-User Information----
    H225:
    H225: Information element identifier = 0x7E (User-User)
    H225: Length of user-user content = 30
    H225: Protocol discriminator = 5 (X.680 / X.691(PER)(ASN.1))
    H225:
    H225: Flags     = 05
    H225: 0... .... = No extension values present in H323-UserInformation
    H225: .0.. .... = user-data is not present
    H225: ..0. .... = No extension values present in h323-uu-pdu
    H225: ...0 .... = nonStandardData is not present
    H225: .... 0... = No extension values present in h323-message-body
    H225: h323-message = 5 (ReleaseComplete)
    H225:
    H225: Flags     = C0
    H225: 1... .... = Extension value(s) present in ReleaseComplete
    H225: .1.. .... = ReleaseCompleteReason is present
    H225: Protocol Id = {0.0.8.2250.0.2}
    H225: H225.0 version = 2
    H225:
    H225: Flags     = 58
    H225: 0... .... = No extension values present in ReleaseCompleteReason
```

```
H225: Reason = 11 (Undefined reason)
H225:
H225:  * ReleaseComplete - extension *
H225: .... .0.. = Extension length determinant
H225: Number of extensions = 1
H225: .... 1... = callIdentifier is present
H225:
H225: Flags     = 00
H225: 0... .... = No extension value(s) present in callIdentifier
H225: Guid = 2DF9BA1C63D8D51190CA000065192D67
```

As a side note, H.323 version 2 (1998) defined a streamlined call establishment procedure known as Fast Connect, illustrated in Figure 4B. (The current publication of H.323 is version 4). Fast Connect shortens the call establishment process, allowing a faster start of the RTP media information. Fast Connect is signaled using a parameter known as the *fastStart* element, which is included in selected H.225 messages. (The Fast Connect procedure is not employed in the NetMeeting example shown above, and is noted here for comparison purposes only.)

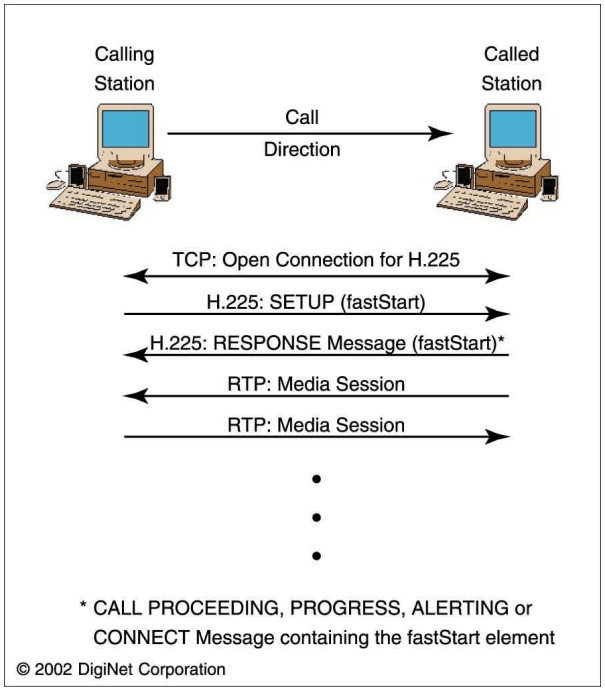

FIGURE 4B. **H.323 Call Setup with Fast Connect Procedure**

In summary, a number of protocols, including TCP, H.225.0, H.245, RTP, and RTCP, are involved in a multimedia communication session over converged network. From the protocol interactions illustrated, and the complexities of some of the messages, it is clear that the network manager's job is made easier by having appropriate tools, such as the *Sniffer* network analyzer, readily available.

4. Looking Ahead

This is the fourth of six technical briefs on Converged Networks sponsored by Sniffer Technologies. Titles of current and future volumes in the series include:

1. Introduction to Converged Networking: A description of concepts and challenges of converged networks, including business, technical, and operational issues.

2. Protocols for the Converged Network: A look at the components of the converged network, the ITU-T and IETF multimedia protocol suites, and the protocols required by each component.

3. Implementing the Voice over IP Network: Issues to consider before you jump in, including existing network utilization, planning for new applications, network design, and interoperability testing.

5. Managing Call Flows Using SIP: The operation of the Session Initiation Protocol (SIP) and the IETF multimedia protocol suite, again illustrated with case studies and output from the *Sniffer* protocol analyzer.

6. Supporting the Converged Network: This concluding paper will deal with ongoing support requirements, including: traffic prioritization, WAN bandwidth optimization, and quality of service optimization.

5. Acronyms and Abbreviations

CCITT	Consultative Committee for International Telephony and Telegraphy
CON	Connection-oriented network service
CNLS	Connectionless network service
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
ENUM	Electronic Numbers
ETSI	European Telecommunications Standards Institute
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITSP	Internet Telephony Service Provider
ITU-T	International Telecommunication Union — Telecommunications Standards Sector
LAN	Local Area Network
MGCP	Media Gateway Control Protocol
MOS	Mean Opinion Score
PBX	Private Branch Exchange
PDA	Personal Digital Assistant
PESQ	Perceptual Evaluation of Speech Quality
PSQM	Perceptual Speech Quality Measurement
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RAS	Registration, Admission, and Status
RSVP	Resource Reservation Protocol
RTCP	Real-time Control Protocol
RTP	Real-time Transport Protocol
RTSP	Real-time Streaming Protocol
SAP	Session Announcement Protocol
SCCP	Skinny Client Control Protocol
SCTP	Stream Control Transmission Protocol
SDP	Session Description Protocol
SIP	Session Initiation Protocol
TCP	Transmission Control Protocol
TIPHON	Telecommunications and Internet Protocol Harmonization Over Networks
VoIP	Voice over Internet Protocol
WAN	Wide Area Network

6. About the Author and Sponsor

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