Voice-over-IP Telephone
-System Design-
Embedded Systems
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System Overview

      The VoIP telephone we're designing is built to support a minimal set of SIP, as we will focus on the necessary implementation of audio I/O, audio trans-coding, and networking.

The phone works as follows:

      We will take audio input from the audio codec and store this data serially and temporarily in a block of BRAM. This audio data will be converted from 16-bit linear to 8-bit ulaw via the G.711 audio codec on the microblaze. The output of the G.711 codec will be stored in parallel in another BRAM block. From there, the sample is ready to be injected into a UDP packet and sent to the ethernet controller buffer.
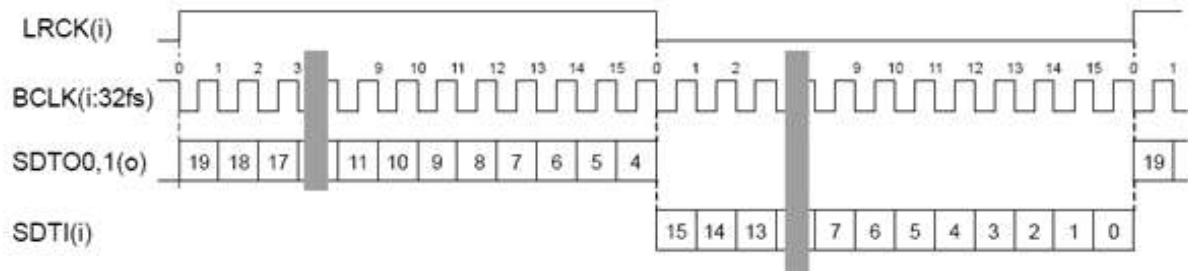
   The components of the board that will be used are:
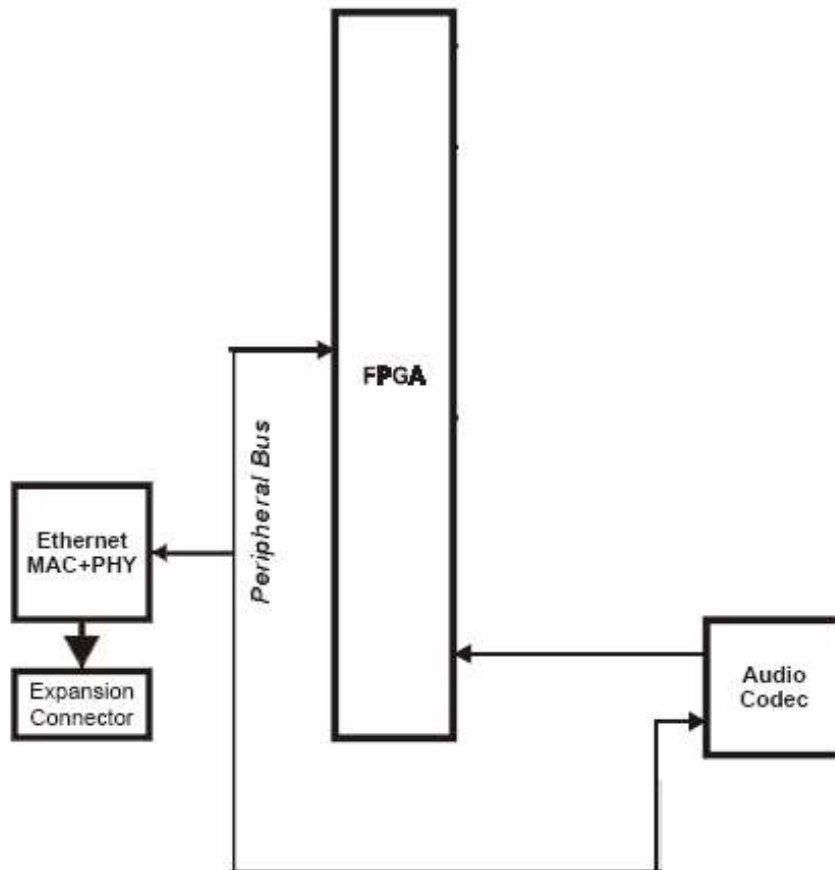
The FPGA will be used as follows:
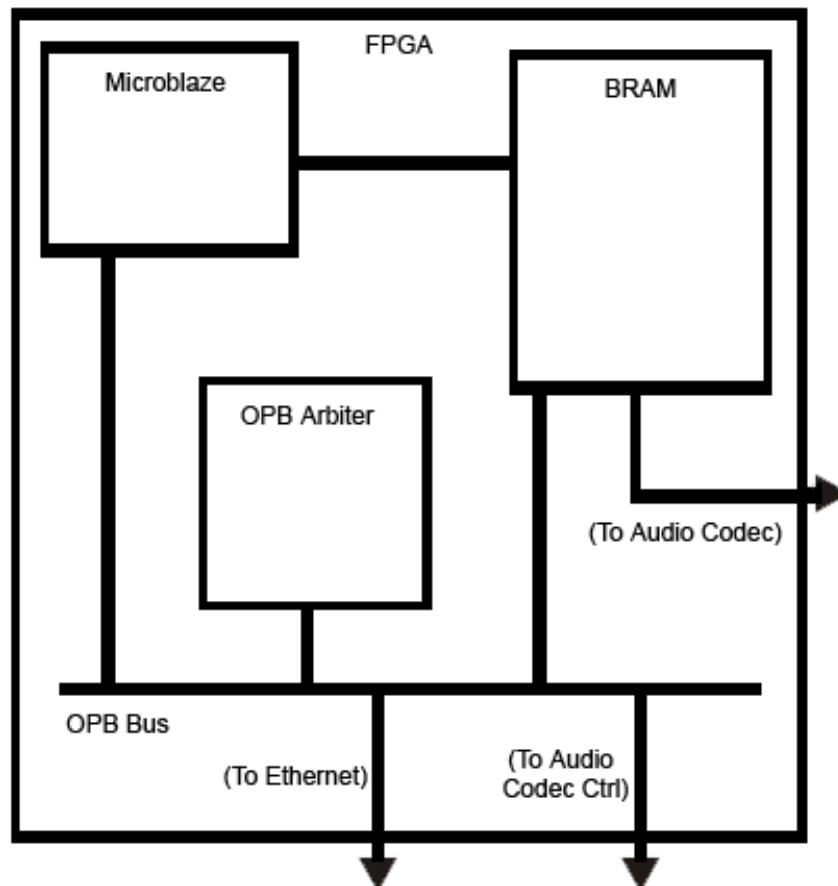
Audio Interface

This is the timing diagram for AK4565 Audio Codec, ignoring stereo input (taken from the Asahi Kasei datasheet, modified for our purposes). When LRCK is low, the codec samples from the right channel, but we are only interested in monophonic recording, so we will ignore the right channel and use the left as the only signal. Running the bit clock (BCLK) at 32 times the sampling frequency (LRCK) we can force the 20-bit codec to serially output 16-bits. By ignoring the stereo nature of the codec we can also operate in half duplex, reading on LRCK high and writing on LRCK low. Hopefully this will simplify timing.
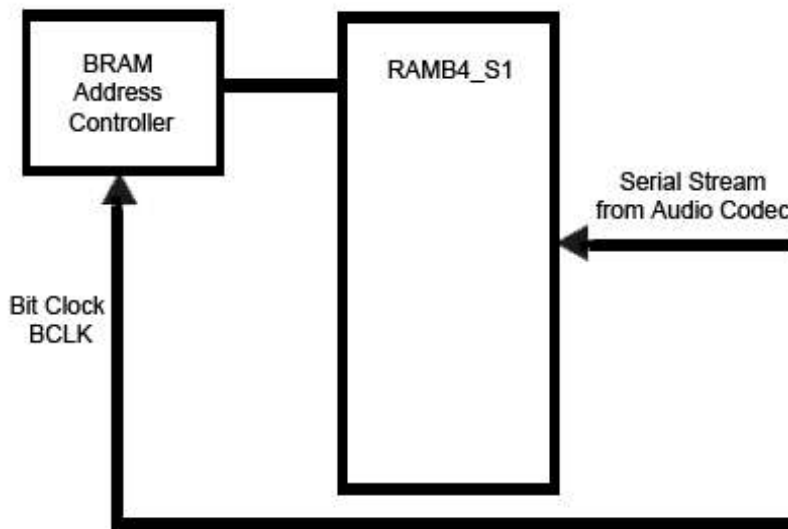
The serial bitstream from the audio codec will be stored into one block of RAMB4_S1 implemented block RAM. This way, a counter can be synchronized with the bit clock (BCLK) of the audio codec to correctly address the incoming bits.

G.711 Encoding

The 16-bit linear data stored in the RAMB4_S1 block will be read by the microblaze and converted into the G.711 format (8-bit μ-law) via code provided by Prof. Schulzrinne (hgs@cs.columbia.edu). This format is preferred for voice telephony because it lowers overall resolution, allowing for faster data transfer, and it is more sensitive to amplitude changes in lower magnitudes. The G.711 encoded audio data will be stored in parallel in a RAMB4_S8 block and is ready to be injected into packets.

Ethernet Controller Interface
Team JAYCam, from last year's class, was able to successfully use the ethernet
controller. We plan to adopt a large deal of their code, which supports UDP
transmission, and augment that code for UDP reception.
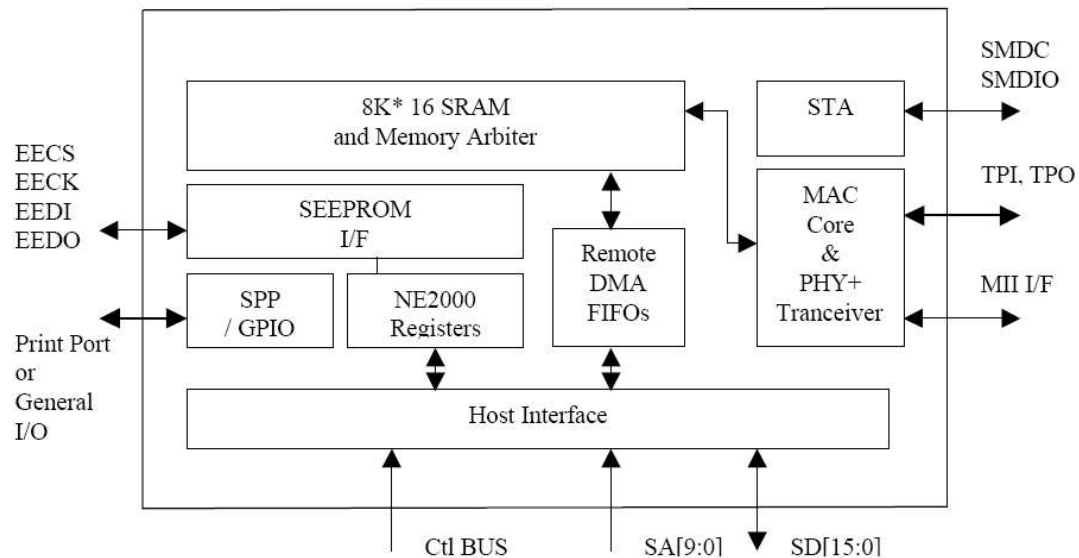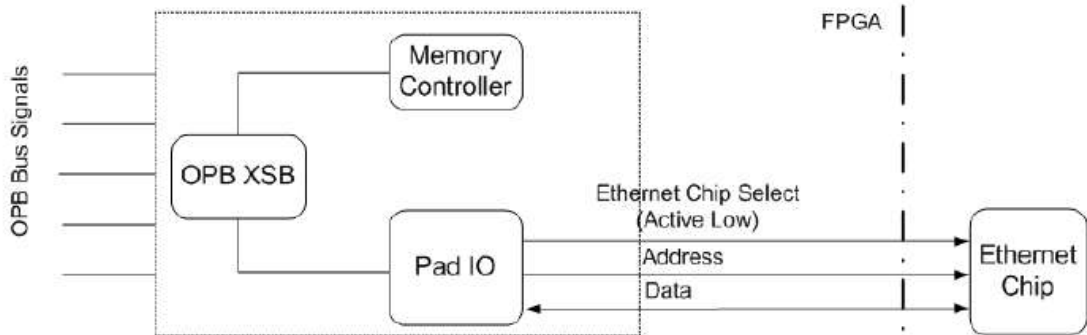
Memory Addressing:
NE2000 registers – x00A00000 – x00A0001F
SRAM Local Memory – x00A04000 – x00A07FFF

Ethernet Buffers
The ethernet 8k x 16 SRAM acts as a buffer for both incoming and outgoing data.
The buffer can be split as desired between these two functions, and we will divide
them evenly, as there is no compelling reason to hold a larger buffer in either
direction.

Data is transmitted by performing a Remote DMA write. Data is received by
performing a Remote DMA read.

Timing – General
We will introduce a 100MHz clock, and the IO Pads of the FPGA support this. This higher clock speed allows for proper state change and signal transfer between the FPGA and ethernet controller.

Timing - Transmission
As noted by JAYCam, the timing diagram provided by the manufacturer is incorrect. The CS, BHE, AE, Add, and WE signals cannot be asserted at the same time, but rather require delay, with CS coming before WE, and all after an overall 5ns initial setup time. This yields a 4-step FSM: 1) All signals except WE asserted 2) WE asserted (making the address and data signals valid) 3) Wait cycle (because DMA may be too slow) 4) Data disabling

Timing – Receiving
We anticipate timing issues with the timing diagram provided by the manufacturer. Nevertheless, we will experiment along the same lines as JAYCam did to solve these problems. The timing diagram for receiving is nearly equivalent to that of transmitting, so the fixes above may allow receiving to work, as well.

Timing Diagram
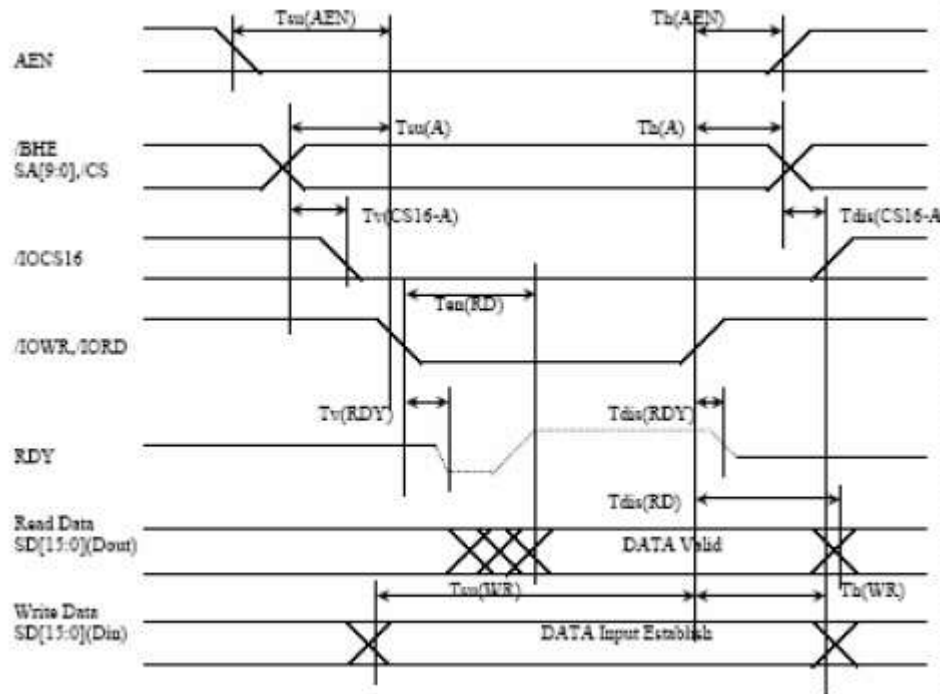
Team JAYCam provides a complete reference on performing the ethernet initialization wit the NE2000 registers for Remote DMA read, and Remote DMA write.

Ethernet Software
Ethernet packets will be assembled by the Microblaze in software by retrieving audio data in the parellel BRAM, generating the entire UDP packet in BRAM, and sending the packet to the Ethernet transmission buffers.

The structure of the IP packet is:

Destination Address	6 Bytes
Source Address	6 Bytes
Length / Type	2 Bytes
Data	46 Bytes
(Pad if < 46 Bytes)	Min.

General Transmit Packet Format

This is not the standard structure for an IP packet, but rather the structure of the packet as received by the ethernet controller, where the data is taken and formed into a standard IP packet. The checksum, etc.. are automatically handled by the controller.

The UDP packet is placed within the IP packet and has the following structure:
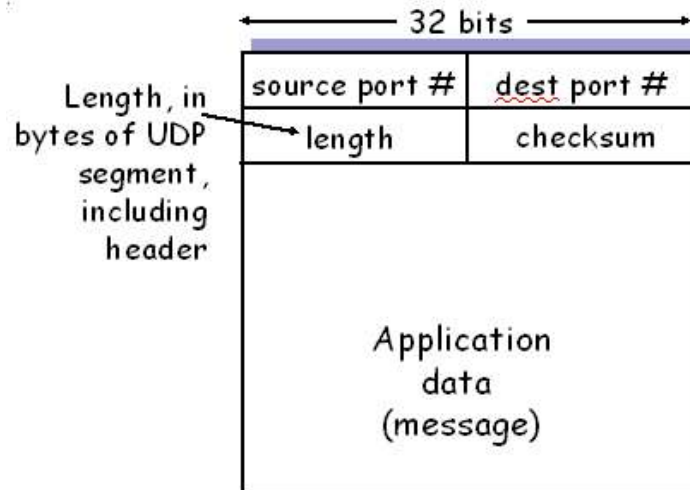
The application data message is specific to the protocol. The protocols we will implement are: SIP, RTP, SDP

SIP/SDP (Application Layer UDP Data Body)
SIP (Session Initiation Protocol) will be used to communicate properly with standard VoIP services. To accomplish this, we also need to implement SDP and RTP. SDP (Session Description Protocol) is used upon connection to agreeon a codec, as in most operation multiple CODECs are available on both the client and server end. In our case, however, we support only G711mu-law, and the SDP response will indicate this. RTP (Real-Time Protocol) is used for audio data transfer during phone calls. This is a simply implemented protocol which, minus a very small header, simply sends the next few samples in the audio stream [observation shows that in general about 20 samples per packet]. Packet sniffed data from a VoIP phone utilizing these protocols is included in Appendix A.
SIP Reference: http://www.ietf.org/rfc/rfc2543.txt

SIP Sequence of Events:
#1: "REGISTER" (see attached packet #1)
      Sent from phone to gateway

      Note that the username and password for the VoIP account are included in the original REGISTER command. Normally, the phone will send a REGISTER without the password and wait for a 401 Unauthorized in return. Our phone will skip this step and send originally with the password. The password has been omitted from the packet sniffed data in the appendix.

#2: "200 OK" (attached packet #2)
      Sent from gateway to phone to acknowledge proper registration

To place a call:
#3: "INVITE" (attached packet #3)
      Phone to gateway:
      Tells the gateway who to add to the phone call; implements SDP in message body to dictate CODECs available

#4: "100 Trying" (attached packet #4)
      Gateway to phone:
      Acknowledges an attempt to call the specified address

#5: "183 Session Progress" with SDP (attached packet #5)
      Gateway to phone:
      Equivalent to knowing that the phone is ringing; SDP indicates selected CODEC

#6: "200 OK" with SDP (attached packet #6)
      Gateway to phone:
      Phone answered; SDP confirms/changes selected CODEC

#7: "ACK" (attached packet #7)
      Phone to gateway:
      Tells the gateway its about to send the audio UDP/RTP stream

#8-#x-1: RTP stream (example packet: attached - #8)

#x: "BYE" (attached packet #9)
    Either direction:
    closes the call

To receive a call:
#3: "INVITE sip:myphonenumber" (attached packet #10)
    Gateway to phone:
    Tells the phone there is an incoming call; message body includes caller ID

#4: "100 Trying" (attached packet #11)
    Phone to gateway:
    Attempting to tell user there is an incoming caller

#5: "180 Ringing" (attached packet #12)
    Phone to gateway:
    The phone is ringing

#6: "200 OK" with SDP (attached packet #13)
    Phone to gateway:
    Phone answered, use this CODEC and talk.

#7: "ACK" (attached packet #14)
    Gateway to phone:
    Time to talk.

#8: "BYE" (attached packet #15)
    Either end:
    Done talking.

Appendix A (SIP/SDP/RTP Packets)

Packet #1 - REGISTER

No. Time   Source   Destination   Protocol Info
  177 8.346622   160.39.194.183   147.135.4.128   SIP   Request: REGISTER
sip:sip.broadvoice.com

Frame 177 (687 bytes on wire, 687 bytes captured)
    Arrival Time: Mar 30, 2005 22:13:17.857530000
    Time delta from previous packet: 0.001406000 seconds
    Time since reference or first frame: 8.346622000 seconds
    Frame Number: 177
    Packet Length: 687 bytes
    Capture Length: 687 bytes
Ethernet II, Src: 00:08:02:62:30:5d, Dst: 00:d0:06:24:c8:0a
    Destination: 00:d0:06:24:c8:0a (160.39.192.1)
    Source: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
    Type: IP (0x0800)
Internet Protocol, Src Addr: 160.39.194.183 (160.39.194.183), Dst Addr: 147.135.4.128
(147.135.4.128)
    Version: 4
    Header length: 20 bytes
    Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
        0000 00.. = Differentiated Services Codepoint: Default (0x00)
        .... ..0. = ECN-Capable Transport (ECT): 0
        ....0 = ECN-CE: 0
    Total Length: 673
    Identification: 0xb376 (45942)
    Flags: 0x00
        0... = Reserved bit: Not set
        .0.. = Don't fragment: Not set
        ..0. = More fragments: Not set
    Fragment offset: 0
    Time to live: 128
    Protocol: UDP (0x11)
    Header checksum: 0x89ef (correct)
    Source: 160.39.194.183 (160.39.194.183)
    Destination: 147.135.4.128 (147.135.4.128)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
    Source port: 5060 (5060)
    Destination port: 5060 (5060)
    Length: 653
    Checksum: 0x95ea (correct)
Session Initiation Protocol
    Request-Line: REGISTER sip:sip.broadvoice.com SIP/2.0
        Method: REGISTER
        Resent Packet: False
    Message Header
        Content-Length: 0
        Contact: <sip:7185042154@160.39.194.183:5060>;events="message-summary"
        Call-ID: C9122422-80FE-4C93-8D0C-3072C699EECD@160.39.194.183
        Max-Forwards: 70
        From: <sip:7185042154@sip.broadvoice.com>;tag=16147744213169
            SIP from address: sip:7185042154@sip.broadvoice.com
            SIP tag: 16147744213169
        CSeq: 2 REGISTER
        To: <sip:7185042154@sip.broadvoice.com>
            SIP to address: sip:7185042154@sip.broadvoice.com
        Via: SIP/2.0/UDP

160.39.194.183;rport;branch=z9hG4bKa027c2b70131c9b1424b6acd0000513400000003
    User-Agent: SJphone/1.50.271d (SJ Labs)
    Authorization: Digest
username="7185042154",realm="BroadWorks",nonce="1112238799238",uri="sip:sip.broadvoice.com",response="20c41fb09886d304d20f94de4d30aacc",algorithm="MD5"

Packet #2 – 200 OK

No.   Time   Source   Destination   Protocol   Info
  185   8.433300   147.135.4.128   160.39.194.183   SIP   Status: 200 OK   (1 bindings)
Frame 185 (466 bytes on wire, 466 bytes captured)
  Arrival Time: Mar 30, 2005 22:13:17.944208000
  Time delta from previous packet: 0.086678000 seconds
  Time since reference or first frame: 8.433300000 seconds
  Frame Number: 185
  Packet Length: 466 bytes
  Capture Length: 466 bytes
Ethernet II, Src: 00:d0:06:24:c8:0a, Dst: 00:08:02:62:30:5d
  Destination: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
  Source: 00:d0:06:24:c8:0a (160.39.192.1)
  Type: IP (0x0800)
Internet Protocol, Src Addr: 147.135.4.128 (147.135.4.128), Dst Addr: 160.39.194.183
(160.39.194.183)
  Version: 4
  Header length: 20 bytes
  Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
    0000 00.. = Differentiated Services Codepoint: Default (0x00)
    .... ..0. = ECN-Capable Transport (ECT): 0
    ....0 = ECN-CE: 0
  Total Length: 452
  Identification: 0x8283 (33411)
  Flags: 0x00
    0... = Reserved bit: Not set
    .0.. = Don't fragment: Not set
    ..0. = More fragments: Not set
  Fragment offset: 0
  Time to live: 50
  Protocol: UDP (0x11)
  Header checksum: 0x09c0 (correct)
  Source: 147.135.4.128 (147.135.4.128)
  Destination: 160.39.194.183 (160.39.194.183)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
  Source port: 5060 (5060)
  Destination port: 5060 (5060)
  Length: 432
  Checksum: 0xb2d3 (correct)
Session Initiation Protocol
  Status-Line: SIP/2.0 200 OK
    Status-Code: 200
    Resent Packet: False
  Message Header
    Call-ID: C9122422-80FE-4C93-8D0C-3072C699EECD@160.39.194.183
    From: <sip:7185042154@sip.broadvoice.com>;tag=16147744213169
      SIP from address: sip:7185042154@sip.broadvoice.com
      SIP tag: 16147744213169
    CSeq: 2 REGISTER
    To: <sip:7185042154@sip.broadvoice.com>;tag=SD309j999-
      SIP to address: sip:7185042154@sip.broadvoice.com
      SIP tag: SD309j999-
    Via: SIP/2.0/UDP
160.39.194.183;received=160.39.194.183;branch=z9hG4bKa027c2b70131c9b1424b6acd000051340
0000003;rport=5060
    Contact: <sip:7185042154@160.39.194.183:5060>;expires=3599;q=0.5
    Content-Length: 0

Packet #3 – INVITE

No.   Time   Source   Destination   Protocol Info
   363 12.801770 160.39.194.183   147.135.4.128   SIP/SDP Request: INVITE
sip:2128535360@sip.broadvoice.com, with session description

Frame 363 (1067 bytes on wire, 1067 bytes captured)
  Arrival Time: Mar 30, 2005 22:13:22.312678000
  Time delta from previous packet: 0.001430000 seconds
  Time since reference or first frame: 12.801770000 seconds
  Frame Number: 363
  Packet Length: 1067 bytes
  Capture Length: 1067 bytes
Ethernet II, Src: 00:08:02:62:30:5d, Dst: 00:d0:06:24:c8:0a
  Destination: 00:d0:06:24:c8:0a (160.39.192.1)
  Source: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
  Type: IP (0x0800)
Internet Protocol, Src Addr: 160.39.194.183 (160.39.194.183), Dst Addr: 147.135.4.128
(147.135.4.128)
  Version: 4
  Header length: 20 bytes
  Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
    0000 00.. = Differentiated Services Codepoint: Default (0x00)
    .... ..0. = ECN-Capable Transport (ECT): 0
    ....0 = ECN-CE: 0
  Total Length: 1053
  Identification: 0xb383 (45955)
  Flags: 0x00
    0... = Reserved bit: Not set
    .0.. = Don't fragment: Not set
    ..0. = More fragments: Not set
  Fragment offset: 0
  Time to live: 128
  Protocol: UDP (0x11)
  Header checksum: 0x8866 (correct)
  Source: 160.39.194.183 (160.39.194.183)
  Destination: 147.135.4.128 (147.135.4.128)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
  Source port: 5060 (5060)
  Destination port: 5060 (5060)
  Length: 1033
  Checksum: 0x2572 (correct)
Session Initiation Protocol
  Request-Line: INVITE sip:2128535360@sip.broadvoice.com SIP/2.0
    Method: INVITE
    Resent Packet: False
  Message Header
    Content-Length: 342
    Contact: <sip:7185042154@160.39.194.183:5060>
    Call-ID: 5694E00C-F38B-40BD-92E1-E5EF69B16030@160.39.194.183
    Content-Type: application/sdp
    From: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com>;tag=16148166814669
      SIP Display info: "Raj Bakhru"
      SIP from address: sip:7185042154@sip.broadvoice.com
      SIP tag: 16148166814669
    CSeq: 2 INVITE
    Max-Forwards: 70
    To: <sip:2128535360@sip.broadvoice.com>

SIP to address: sip:2128535360@sip.broadvoice.com
Via: SIP/2.0/UDP
160.39.194.183;rport;branch=z9hG4bKa027c2b700000019424b6ad2000065fc00000008
User-Agent: SJphone/1.50.271d (SJ Labs)
Authorization: Digest
username="7185042154",realm="BroadWorks",nonce="1112238803690",uri="sip:2128535360@sip.
broadvoice.com",response="3db01ba90c1324a3ab9b29eb1e0aadcf",algorithm="MD5"
Message body
Session Description Protocol
Session Description Protocol Version (v): 0
Owner/Creator, Session Id (o): - 3321227602 3321227602 IN IP4 160.39.194.183
Owner Username: -
Session ID: 3321227602
Session Version: 3321227602
Owner Network Type: IN
Owner Address Type: IP4
Owner Address: 160.39.194.183
Session Name (s): SJphone
Connection Information (c): IN IP4 160.39.194.183
Connection Network Type: IN
Connection Address Type: IP4
Connection Address: 160.39.194.183
Time Description, active time (t): 0 0
Session Start Time: 0
Session Stop Time: 0
Session Attribute (a): direction:passive
Session Attribute Fieldname: direction
Session Attribute Value: passive
Media Description, name and address (m): audio 49152 RTP/AVP 3 97 98 8 0 101
Media Type: audio
Media Port: 49152
Media Proto: RTP/AVP
Media Format: GSM 06.10
Media Format: 97
Media Format: 98
Media Format: ITU-T G.711 PCMA
Media Format: ITU-T G.711 PCMU
Media Format: 101
Media Attribute (a): rtpmap:3 GSM/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 3 GSM/8000
Media Attribute (a): rtpmap:97 iLBC/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 97 iLBC/8000
Media Attribute (a): rtpmap:98 iLBC/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 98 iLBC/8000
Media Attribute (a): fmtp:98 mode=20
Media Attribute Fieldname: fmtp
Media Attribute Value: 98 mode=20
Media Attribute (a): rtpmap:8 PCMA/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 8 PCMA/8000
Media Attribute (a): rtpmap:0 PCMU/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 0 PCMU/8000
Media Attribute (a): rtpmap:101 telephone-event/8000

Media Attribute Fieldname: rtpmap
Media Attribute Value: 101 telephone-event/8000
Media Attribute (a): fmtp:101 0-11,16
Media Attribute Fieldname: fmtp
Media Attribute Value: 101 0-11,16

Packet #4 – TRYING

No.   Time   Source   Destination   Protocol Info
  365 12.847772 147.135.4.128   160.39.194.183   SIP   Status: 100 Trying

Frame 365 (380 bytes on wire, 380 bytes captured)
   Arrival Time: Mar 30, 2005 22:13:22.358680000
   Time delta from previous packet: 0.046002000 seconds
   Time since reference or first frame: 12.847772000 seconds
   Frame Number: 365
   Packet Length: 380 bytes
   Capture Length: 380 bytes
Ethernet II, Src: 00:d0:06:24:c8:0a, Dst: 00:08:02:62:30:5d
   Destination: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
   Source: 00:d0:06:24:c8:0a (160.39.192.1)
   Type: IP (0x0800)
Internet Protocol, Src Addr: 147.135.4.128 (147.135.4.128), Dst Addr: 160.39.194.183
(160.39.194.183)
   Version: 4
   Header length: 20 bytes
   Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
     0000 00.. = Differentiated Services Codepoint: Default (0x00)
     .... ..0. = ECN-Capable Transport (ECT): 0
     ....0 = ECN-CE: 0
   Total Length: 366
   Identification: 0x849e (33950)
   Flags: 0x00
     0... = Reserved bit: Not set
     .0.. = Don't fragment: Not set
     ..0. = More fragments: Not set
   Fragment offset: 0
   Time to live: 50
   Protocol: UDP (0x11)
   Header checksum: 0x07fb (correct)
   Source: 147.135.4.128 (147.135.4.128)
   Destination: 160.39.194.183 (160.39.194.183)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
   Source port: 5060 (5060)
   Destination port: 5060 (5060)
   Length: 346
   Checksum: 0x1e7f (correct)
Session Initiation Protocol
   Status-Line: SIP/2.0 100 Trying
     Status-Code: 100
     Resent Packet: False
   Message Header
     Call-ID: 5694E00C-F38B-40BD-92E1-E5EF69B16030@160.39.194.183
     From: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com>;tag=16148166814669
       SIP Display info: "Raj Bakhru"
       SIP from address: sip:7185042154@sip.broadvoice.com
       SIP tag: 16148166814669
     CSeq: 2 INVITE
     To: <sip:2128535360@sip.broadvoice.com>
       SIP to address: sip:2128535360@sip.broadvoice.com
     Via: SIP/2.0/UDP
160.39.194.183;received=160.39.194.183;branch=z9hG4bKa027c2b700000019424b6ad2000065fc00
000008;rport=5060

Packet #5 – SESSION PROGRESS

No. Time   Source   Destination   Protocol Info
   412 13.576174 147.135.4.128   160.39.194.183   SIP/SDP Status: 183 Session Progress,
with session description

Frame 412 (1008 bytes on wire, 1008 bytes captured)
   Arrival Time: Mar 30, 2005 22:13:23.087082000
   Time delta from previous packet: 0.728402000 seconds
   Time since reference or first frame: 13.576174000 seconds
   Frame Number: 412
   Packet Length: 1008 bytes
   Capture Length: 1008 bytes
Ethernet II, Src: 00:d0:06:24:c8:0a, Dst: 00:08:02:62:30:5d
   Destination: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
   Source: 00:d0:06:24:c8:0a (160.39.192.1)
   Type: IP (0x0800)
Internet Protocol, Src Addr: 147.135.4.128 (147.135.4.128), Dst Addr: 160.39.194.183
(160.39.194.183)
   Version: 4
   Header length: 20 bytes
   Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
      0000 00.. = Differentiated Services Codepoint: Default (0x00)
      .... ..0. = ECN-Capable Transport (ECT): 0
      ....0 = ECN-CE: 0
   Total Length: 994
   Identification: 0x8506 (34054)
   Flags: 0x00
      0... = Reserved bit: Not set
      .0.. = Don't fragment: Not set
      ..0. = More fragments: Not set
   Fragment offset: 0
   Time to live: 50
   Protocol: UDP (0x11)
   Header checksum: 0x051f (correct)
   Source: 147.135.4.128 (147.135.4.128)
   Destination: 160.39.194.183 (160.39.194.183)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
   Source port: 5060 (5060)
   Destination port: 5060 (5060)
   Length: 974
   Checksum: 0x9b6d (correct)
Session Initiation Protocol
   Status-Line: SIP/2.0 183 Session Progress
      Status-Code: 183
      Resent Packet: False
   Message Header
      Call-ID: 5694E00C-F38B-40BD-92E1-E5EF69B16030@160.39.194.183
      From: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com>;tag=16148166814669
         SIP Display info: "Raj Bakhru"
         SIP from address: sip:7185042154@sip.broadvoice.com
         SIP tag: 16148166814669
      CSeq: 2 INVITE
      To: <sip:2128535360@sip.broadvoice.com>;tag=SD3o1b999-1895403986-1112238804464
         SIP to address: sip:2128535360@sip.broadvoice.com
         SIP tag: SD3o1b999-1895403986-1112238804464
      Via: SIP/2.0/UDP
160.39.194.183;received=160.39.194.183;branch=z9hG4bKa027c2b700000019424b6ad2000065fc00

000008;rport=5060

    Allow: ACK,BYE,CANCEL,INFO,INVITE,OPTIONS,PRACK,REFER,UPDATE,NOTIFY

    Supported: 100rel,timer

    Contact: <sip:2128535360@147.135.4.128:5060;bvoice=ACME-ntqjclfhfev2b;ep=147.135.4.129;transport=udp>

    Session: Media

    Remote-Party-ID: <sip:2128535360@147.135.4.129;user=phone;bvoice=ACME-06t5tpji5ub7e>;screen=yes;party=called;privacy=off;id-type=subscriber

    Content-Type: application/sdp

    Content-Length: 173

  Message body

    Session Description Protocol

      Session Description Protocol Version (v): 0

      Owner/Creator, Session Id (o): BroadWorks 24089752 1 IN IP4 147.135.4.128

        Owner Username: BroadWorks

        Session ID: 24089752

        Session Version: 1

        Owner Network Type: IN

        Owner Address Type: IP4

        Owner Address: 147.135.4.128

      Session Name (s): -

      Connection Information (c): IN IP4 147.135.4.128

        Connection Network Type: IN

        Connection Address Type: IP4

        Connection Address: 147.135.4.128

      Time Description, active time (t): 0 0

        Session Start Time: 0

        Session Stop Time: 0

      Media Description, name and address (m): audio 13776 RTP/AVP 8 101

        Media Type: audio

        Media Port: 13776

        Media Proto: RTP/AVP

        Media Format: ITU-T G.711 PCMA

        Media Format: 101

      Media Attribute (a): rtpmap:8 PCMA/8000

        Media Attribute Fieldname: rtpmap

        Media Attribute Value: 8 PCMA/8000

      Media Attribute (a): rtpmap:101 telephone-event/8000

        Media Attribute Fieldname: rtpmap

        Media Attribute Value: 101 telephone-event/8000

Packet #6 – 200 OK

No.   Time   Source   Destination   Protocol Info
   1051 18.760866   147.135.4.128   160.39.194.183   S IP/SDP Status: 200 OK, with session
description

Frame 1051 (1020 bytes on wire, 1020 bytes captured)
   Arrival Time: Mar 30, 2005 22:13:28.271774000
   Time delta from previous packet: 5.184692000 seconds
   Time since reference or first frame: 18.760866000 seconds
   Frame Number: 1051
   Packet Length: 1020 bytes
   Capture Length: 1020 bytes
Ethernet II, Src: 00:d0:06:24:c8:0a, Dst: 00:08:02:62:30:5d
   Destination: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
   Source: 00:d0:06:24:c8:0a (160.39.192.1)
   Type: IP (0x0800)
Internet Protocol, Src Addr: 147.135.4.128 (147.135.4.128), Dst Addr: 160.39.194.183
(160.39.194.183)
   Version: 4
   Header length: 20 bytes
   Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
     0000 00.. = Differentiated Services Codepoint: Default (0x00)
     .... ..0. = ECN-Capable Transport (ECT): 0
     ....0 = ECN-CE: 0
   Total Length: 1006
   Identification: 0x8770 (34672)
   Flags: 0x00
     0... = Reserved bit: Not set
     .0.. = Don't fragment: Not set
     ..0. = More fragments: Not set
   Fragment offset: 0
   Time to live: 50
   Protocol: UDP (0x11)
   Header checksum: 0x02a9 (correct)
   Source: 147.135.4.128 (147.135.4.128)
   Destination: 160.39.194.183 (160.39.194.183)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
   Source port: 5060 (5060)
   Destination port: 5060 (5060)
   Length: 986
   Checksum: 0xb1d2 (correct)
Session Initiation Protocol
   Status-Line: SIP/2.0 200 OK
     Status-Code: 200
     Resent Packet: False
   Message Header
     Call-ID: 5694E00C-F38B-40BD-92E1-E5EF69B16030@160.39.194.183
     From: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com>;tag=16148166814669
       SIP Display info: "Raj Bakhru"
       SIP from address: sip:7185042154@sip.broadvoice.com
       SIP tag: 16148166814669
     CSeq: 2 INVITE
     To: <sip:2128535360@sip.broadvoice.com>;tag=SD3o1b999-1895403986-1112238804464
       SIP to address: sip:2128535360@sip.broadvoice.com
       SIP tag: SD3o1b999-1895403986-1112238804464
     Via: SIP/2.0/UDP
160.39.194.183;received=160.39.194.183;branch=z9hG4bKa027c2b700000019424b6ad2000065fc00

000008;rport=5060
    Allow: ACK,BYE,CANCEL,INFO,INVITE,OPTIONS,PRACK,REFER,UPDATE,NOTIFY
    Supported: 100rel,timer
    Accept: application/sdp,application/dtmf
    Contact: <sip:2128535360@147.135.4.128:5060;bvoice=ACME-
ntqjclfhfev2b;ep=147.135.4.129;transport=udp>
    Remote-Party-ID: <sip:2128535360@147.135.4.129;user=phone;bvoice=ACME-
06t5tpji5ub7e>;screen=yes;party=called;privacy=off;id-type=subscriber
    Content-Type: application/sdp
    Content-Length: 173
  Message body
    Session Description Protocol
        Session Description Protocol Version (v): 0
        Owner/Creator, Session Id (o): BroadWorks 24089752 2 IN IP4 147.135.4.128
            Owner Username: BroadWorks
            Session ID: 24089752
            Session Version: 2
            Owner Network Type: IN
            Owner Address Type: IP4
            Owner Address: 147.135.4.128
        Session Name (s): -
        Connection Information (c): IN IP4 147.135.4.128
            Connection Network Type: IN
            Connection Address Type: IP4
            Connection Address: 147.135.4.128
        Time Description, active time (t): 0 0
            Session Start Time: 0
            Session Stop Time: 0
        Media Description, name and address (m): audio 13776 RTP/AVP 8 101
            Media Type: audio
            Media Port: 13776
            Media Proto: RTP/AVP
            Media Format: ITU-T G.711 PCMA
            Media Format: 101
        Media Attribute (a): rtpmap:8 PCMA/8000
            Media Attribute Fieldname: rtpmap
            Media Attribute Value: 8 PCMA/8000
        Media Attribute (a): rtpmap:101 telephone-event/8000
            Media Attribute Fieldname: rtpmap
            Media Attribute Value: 101 telephone-event/8000

Packet #7 – ACK

No.   Time   Source   Destination   Protocol Info
  1053 18.765586   160.39.194.183   147.135.4.128   S IP   Request: ACK
sip:2128535360@147.135.4.128:5060;transport=udp;bvoice=ACME-ntqjclfhfev2b;ep=147.135.4.129

Frame 1053 (584 bytes on wire, 584 bytes captured)
    Arrival Time: Mar 30, 2005 22:13:28.276494000
    Time delta from previous packet: 0.004720000 seconds
    Time since reference or first frame: 18.765586000 seconds
    Frame Number: 1053
    Packet Length: 584 bytes
    Capture Length: 584 bytes
Ethernet II, Src: 00:08:02:62:30:5d, Dst: 00:d0:06:24:c8:0a
    Destination: 00:d0:06:24:c8:0a (160.39.192.1)
    Source: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
    Type: IP (0x0800)
Internet Protocol, Src Addr: 160.39.194.183 (160.39.194.183), Dst Addr: 147.135.4.128
(147.135.4.128)
    Version: 4
    Header length: 20 bytes
    Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
        0000 00.. = Differentiated Services Codepoint: Default (0x00)
        .... ..0. = ECN-Capable Transport (ECT): 0
        ....0 = ECN-CE: 0
    Total Length: 570
    Identification: 0xb487 (46215)
    Flags: 0x00
        0... = Reserved bit: Not set
        .0.. = Don't fragment: Not set
        ..0. = More fragments: Not set
    Fragment offset: 0
    Time to live: 128
    Protocol: UDP (0x11)
    Header checksum: 0x8945 (correct)
    Source: 160.39.194.183 (160.39.194.183)
    Destination: 147.135.4.128 (147.135.4.128)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
    Source port: 5060 (5060)
    Destination port: 5060 (5060)
    Length: 550
    Checksum: 0x33b6 (correct)
Session Initiation Protocol
    Request-Line: ACK sip:2128535360@147.135.4.128:5060;transport=udp;bvoice=ACME-
ntqjclfhfev2b;ep=147.135.4.129 SIP/2.0
        Method: ACK
        Resent Packet: False
    Message Header
        Content-Length: 0
        Contact: <sip:7185042154@160.39.194.183:5060>
        Call-ID: 5694E00C-F38B-40BD-92E1-E5EF69B16030@160.39.194.183
        Max-Forwards: 70
        CSeq: 2 ACK
        From: <sip:7185042154@sip.broadvoice.com>;tag=16148166814669
            SIP from address: sip:7185042154@sip.broadvoice.com
            SIP tag: 16148166814669
        To: <sip:2128535360@sip.broadvoice.com>;tag=SD3o1b999-1895403986-1112238804464
            SIP to address: sip:2128535360@sip.broadvoice.com

SIP tag: SD3o1b999-1895403986-1112238804464
User-Agent: SJphone/1.50.271d (SJ Labs)
Via: SIP/2.0/UDP
160.39.194.183;rport;branch=z9hG4bKa027c2b70131c9b1424b6ad800001c4b0000000c

Packet #8 – RTP Audio Data

No.   Time   Source   Destination   Protocol Info
  368 12.975238 147.135.4.128   160.39.194.183   RTP   Payload type=ITU-T G.711
PCMA, SSRC=238265358, Seq=12506, Time=56541695

Frame 368 (214 bytes on wire, 214 bytes captured)
    Arrival Time: Mar 30, 2005 22:13:22.486146000
    Time delta from previous packet: 12.975238000 seconds
    Time since reference or first frame: 12.975238000 seconds
    Frame Number: 368
    Packet Length: 214 bytes
    Capture Length: 214 bytes
Ethernet II, Src: 00:d0:06:24:c8:0a, Dst: 00:08:02:62:30:5d
    Destination: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
    Source: 00:d0:06:24:c8:0a (160.39.192.1)
    Type: IP (0x0800)
Internet Protocol, Src Addr: 147.135.4.128 (147.135.4.128), Dst Addr: 160.39.194.183
(160.39.194.183)
    Version: 4
    Header length: 20 bytes
    Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
        0000 00.. = Differentiated Services Codepoint: Default (0x00)
        .... ..0. = ECN-Capable Transport (ECT): 0
        ....0 = ECN-CE: 0
    Total Length: 200
    Identification: 0x543e (21566)
    Flags: 0x00
        0... = Reserved bit: Not set
        .0.. = Don't fragment: Not set
        ..0. = More fragments: Not set
    Fragment offset: 0
    Time to live: 44
    Protocol: UDP (0x11)
    Header checksum: 0x3f01 (correct)
    Source: 147.135.4.128 (147.135.4.128)
    Destination: 160.39.194.183 (160.39.194.183)
User Datagram Protocol, Src Port: 13776 (13776), Dst Port: 49152 (49152)
    Source port: 13776 (13776)
    Destination port: 49152 (49152)
    Length: 180
    Checksum: 0x127a (correct)
Real-Time Transport Protocol
    Stream setup by SDP (frame 363)
        Setup frame: 363
        Setup Method: SDP
    10.. .... = Version: RFC 1889 Version (2)
    ..0. .... = Padding: False
    ...0 .... = Extension: False
    .... 0000 = Contributing source identifiers count: 0
    0... .... = Marker: False
    .000 1000 = Payload type: ITU-T G.711 PCMA (8)
    Sequence number: 12506
    Timestamp: 56541695
    Synchronization Source identifier: 238265358
    Payload: D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5D5...

Packet #9 – BYE

No.   Time   Source   Destination   Protocol Info
  2079 27.062696   147.135.4.128   160.39.194.183   S IP   Request: BYE
sip:7185042154@160.39.194.183:5060
Frame 2079 (442 bytes on wire, 442 bytes captured)
    Arrival Time: Mar 30, 2005 22:13:36.573604000
    Time delta from previous packet: 8.297110000 seconds
    Time since reference or first frame: 27.062696000 seconds
    Frame Number: 2079
    Packet Length: 442 bytes
    Capture Length: 442 bytes
Ethernet II, Src: 00:d0:06:24:c8:0a, Dst: 00:08:02:62:30:5d
    Destination: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
    Source: 00:d0:06:24:c8:0a (160.39.192.1)
    Type: IP (0x0800)
Internet Protocol, Src Addr: 147.135.4.128 (147.135.4.128), Dst Addr: 160.39.194.183
(160.39.194.183)
    Version: 4
    Header length: 20 bytes
    Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
        0000 00.. = Differentiated Services Codepoint: Default (0x00)
        .... ..0. = ECN-Capable Transport (ECT): 0
        ....0 = ECN-CE: 0
    Total Length: 428
    Identification: 0x8bd6 (35798)
    Flags: 0x00
        0... = Reserved bit: Not set
        .0.. = Don't fragment: Not set
        ..0. = More fragments: Not set
    Fragment offset: 0
    Time to live: 50
    Protocol: UDP (0x11)
    Header checksum: 0x0085 (correct)
    Source: 147.135.4.128 (147.135.4.128)
    Destination: 160.39.194.183 (160.39.194.183)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
    Source port: 5060 (5060)
    Destination port: 5060 (5060)
    Length: 408
    Checksum: 0x7c65 (correct)
Session Initiation Protocol
    Request-Line: BYE sip:7185042154@160.39.194.183:5060 SIP/2.0
        Method: BYE
        Resent Packet: False
    Message Header
        Via: SIP/2.0/UDP 147.135.4.128:5060;branch=z9hG4bK2qi4i3304o41e94fk701.1sr
        From: <sip:2128535360@sip.broadvoice.com>;tag=SD3o1b999-1895403986-1112238804464
            SIP from address: sip:2128535360@sip.broadvoice.com
            SIP tag: SD3o1b999-1895403986-1112238804464
        To: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com>;tag=16148166814669
            SIP Display info: "Raj Bakhru"
            SIP to address: sip:7185042154@sip.broadvoice.com
            SIP tag: 16148166814669
        Call-ID: 5694E00C-F38B-40BD-92E1-E5EF69B16030@160.39.194.183
        CSeq: 994878884 BYE
        Max-Forwards: 69
        Content-Length: 0

Packet #10 – INVITE

No.   Time   Source   Destination   Protocol Info
   464 19.227426 147.135.4.128   160.39.194.183   SIP/SDP Request: INVITE
sip:7185042154@160.39.194.183:5060, with session description

Frame 464 (1036 bytes on wire, 1036 bytes captured)
   Arrival Time: Mar 30, 2005 23:17:22.089318000
   Time delta from previous packet: 19.227426000 seconds
   Time since reference or first frame: 19.227426000 seconds
   Frame Number: 464
   Packet Length: 1036 bytes
   Capture Length: 1036 bytes
Ethernet II, Src: 00:d0:06:24:c8:0a, Dst: 00:08:02:62:30:5d
   Destination: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
   Source: 00:d0:06:24:c8:0a (160.39.192.1)
   Type: IP (0x0800)
Internet Protocol, Src Addr: 147.135.4.128 (147.135.4.128), Dst Addr: 160.39.194.183
(160.39.194.183)
   Version: 4
   Header length: 20 bytes
   Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
     0000 00.. = Differentiated Services Codepoint: Default (0x00)
     .... ..0. = ECN-Capable Transport (ECT): 0
     ....0 = ECN-CE: 0
   Total Length: 1022
   Identification: 0xd0c7 (53447)
   Flags: 0x00
     0... = Reserved bit: Not set
     .0.. = Don't fragment: Not set
     ..0. = More fragments: Not set
   Fragment offset: 0
   Time to live: 50
   Protocol: UDP (0x11)
   Header checksum: 0xb941 (correct)
   Source: 147.135.4.128 (147.135.4.128)
   Destination: 160.39.194.183 (160.39.194.183)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
   Source port: 5060 (5060)
   Destination port: 5060 (5060)
   Length: 1002
   Checksum: 0xea93 (correct)
Session Initiation Protocol
   Request-Line: INVITE sip:7185042154@160.39.194.183:5060 SIP/2.0
     Method: INVITE
     Resent Packet: False
   Message Header
     Via: SIP/2.0/UDP 147.135.4.128:5060;branch=z9hG4bK2qi23s20a0t1b94gv001.1sr
     From: "Cell Phone PA"<sip:6102567675@147.135.4.129;user=phone;bvoice=ACME-
06t5tpji5ub7e>;tag=SD5oukc01-1051083302-1112242643515
       SIP Display info: "Cell Phone PA"
       SIP from address: sip:6102567675@147.135.4.129
       SIP tag: SD5oukc01-1051083302-1112242643515
     To: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com;user=phone>
       SIP Display info: "Raj Bakhru"
       SIP to address: sip:7185042154@sip.broadvoice.com
     Call-ID: SD5oukc01-d2e552914b255026f158ce0c2a5ce75f-js19002
     CSeq: 996798750 INVITE

Contact: <sip:6102567675@147.135.4.128:5060;bvoice=ACME-
ntqjclfhfev2b;ep=147.135.4.129;transport=udp>
Allow: ACK,BYE,CANCEL,INFO,INVITE,OPTIONS,PRACK,REFER,UPDATE,NOTIFY
Supported: 100rel,timer
Min-SE: 60
Accept: application/sdp,application/dtmf
Max-Forwards: 69
Content-Type: application/sdp
Content-Length: 264
Message body
Session Description Protocol
Session Description Protocol Version (v): 0
Owner/Creator, Session Id (o): BroadWorks 24132589 1 IN IP4 147.135.4.128
Owner Username: BroadWorks
Session ID: 24132589
Session Version: 1
Owner Network Type: IN
Owner Address Type: IP4
Owner Address: 147.135.4.128
Session Name (s): -
Connection Information (c): IN IP4 147.135.4.128
Connection Network Type: IN
Connection Address Type: IP4
Connection Address: 147.135.4.128
Time Description, active time (t): 0 0
Session Start Time: 0
Session Stop Time: 0
Media Description, name and address (m): audio 12484 RTP/AVP 0 8 96 18 101
Media Type: audio
Media Port: 12484
Media Proto: RTP/AVP
Media Format: ITU-T G.711 PCMU
Media Format: ITU-T G.711 PCMA
Media Format: 96
Media Format: ITU-T G.729
Media Format: 101
Media Attribute (a): ptime:20
Media Attribute Fieldname: ptime
Media Attribute Value: 20
Media Attribute (a): rtpmap:0 PCMU/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 0 PCMU/8000
Media Attribute (a): rtpmap:8 PCMA/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 8 PCMA/8000
Media Attribute (a): rtpmap:96 G726-32/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 96 G726-32/8000
Media Attribute (a): rtpmap:18 G729/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 18 G729/8000
Media Attribute (a): rtpmap:101 telephone-event/8000
Media Attribute Fieldname: rtpmap
Media Attribute Value: 101 telephone-event/8000

Packet #11 – TRYING

No.   Time   Source   Destination   Protocol Info
   467 19.257949   160.39.194.183   147.135.4.128   SIP   Status: 100 Trying
Frame 467 (478 bytes on wire, 478 bytes captured)
   Arrival Time: Mar 30, 2005 23:17:22.119841000
   Time delta from previous packet: 0.030523000 seconds
   Time since reference or first frame: 19.257949000 seconds
   Frame Number: 467
   Packet Length: 478 bytes
   Capture Length: 478 bytes
Ethernet II, Src: 00:08:02:62:30:5d, Dst: 00:d0:06:24:c8:0a
   Destination: 00:d0:06:24:c8:0a (160.39.192.1)
   Source: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
   Type: IP (0x0800)
Internet Protocol, Src Addr: 160.39.194.183 (160.39.194.183), Dst Addr: 147.135.4.128
(147.135.4.128)
   Version: 4
   Header length: 20 bytes
   Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
      0000 00.. = Differentiated Services Codepoint: Default (0x00)
      .... ..0. = ECN-Capable Transport (ECT): 0
      ....0 = ECN-CE: 0
   Total Length: 464
   Identification: 0xcd5a (52570)
   Flags: 0x00
      0... = Reserved bit: Not set
      .0.. = Don't fragment: Not set
      ..0. = More fragments: Not set
   Fragment offset: 0
   Time to live: 128
   Protocol: UDP (0x11)
   Header checksum: 0x70dc (correct)
   Source: 160.39.194.183 (160.39.194.183)
   Destination: 147.135.4.128 (147.135.4.128)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
   Source port: 5060 (5060)
   Destination port: 5060 (5060)
   Length: 444
   Checksum: 0xea2e (correct)
Session Initiation Protocol
   Status-Line: SIP/2.0 100 Trying
      Status-Code: 100
      Resent Packet: False
   Message Header
      Content-Length: 0
      Call-ID: SD5oukc01-d2e552914b255026f158ce0c2a5ce75f-js19002
      CSeq: 996798750 INVITE
      From: <sip:6102567675@147.135.4.129;user=phone;bvoice=ACME-
06t5tpji5ub7e>;tag=SD5oukc01-1051083302-1112242643515
         SIP from address: sip:6102567675@147.135.4.129
         SIP tag: SD5oukc01-1051083302-1112242643515
      To: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com;user=phone>;tag=16532169023379
         SIP Display info: "Raj Bakhru"
         SIP to address: sip:7185042154@sip.broadvoice.com
         SIP tag: 16532169023379
      Server: SJphone/1.50.271d (SJ Labs)
      Via: SIP/2.0/UDP 147.135.4.128:5060;branch=z9hG4bK2qi23s20a0t1b94gv001.1sr

Packet #12 – RINGING

No.   Time   Source   Destination   Protocol Info
   489 19.543316 160.39.194.183   147.135.4.128   SIP   Status: 180 Ringing

Frame 489 (526 bytes on wire, 526 bytes captured)
   Arrival Time: Mar 30, 2005 23:17:22.405208000
   Time delta from previous packet: 0.285367000 seconds
   Time since reference or first frame: 19.543316000 seconds
   Frame Number: 489
   Packet Length: 526 bytes
   Capture Length: 526 bytes
Ethernet II, Src: 00:08:02:62:30:5d, Dst: 00:d0:06:24:c8:0a
   Destination: 00:d0:06:24:c8:0a (160.39.192.1)
   Source: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
   Type: IP (0x0800)
Internet Protocol, Src Addr: 160.39.194.183 (160.39.194.183), Dst Addr: 147.135.4.128
(147.135.4.128)
   Version: 4
   Header length: 20 bytes
   Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
     0000 00.. = Differentiated Services Codepoint: Default (0x00)
   Total Length: 512
   Identification: 0xcd5b (52571)
   Flags: 0x00
     0... = Reserved bit: Not set
     .0.. = Don't fragment: Not set
     ..0. = More fragments: Not set
   Fragment offset: 0
   Time to live: 128
   Protocol: UDP (0x11)
   Header checksum: 0x70ab (correct)
   Source: 160.39.194.183 (160.39.194.183)
   Destination: 147.135.4.128 (147.135.4.128)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
   Source port: 5060 (5060)
   Destination port: 5060 (5060)
   Length: 492
   Checksum: 0xf70e (correct)
Session Initiation Protocol
   Status-Line: SIP/2.0 180 Ringing
     Status-Code: 180
     Resent Packet: False
   Message Header
     Content-Length: 0
     Contact: <sip:7185042154@160.39.194.183:5060>
     Call-ID: SD5oukc01-d2e552914b255026f158ce0c2a5ce75f-js19002
     CSeq: 996798750 INVITE
     From: <sip:6102567675@147.135.4.129;user=phone;bvoice=ACME-
06t5tpji5ub7e>;tag=SD5oukc01-1051083302-1112242643515
       SIP from address: sip:6102567675@147.135.4.129
       SIP tag: SD5oukc01-1051083302-1112242643515
     To: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com;user=phone>;tag=16532169023379
       SIP Display info: "Raj Bakhru"
       SIP to address: sip:7185042154@sip.broadvoice.com
       SIP tag: 16532169023379
     Server: SJphone/1.50.271d (SJ Labs)
     Via: SIP/2.0/UDP 147.135.4.128:5060;branch=z9hG4bK2qi23s20a0t1b94gv001.1sr

Packet #13 – 200 OK

No.   Time   Source   Destination   Protocol Info
    586 21.207952 160.39.194.183   147.135.4.128   SIP/SDP Status: 200 OK, with session description

Frame 586 (778 bytes on wire, 778 bytes captured)
    Arrival Time: Mar 30, 2005 23:17:24.069844000
    Time delta from previous packet: 1.664636000 seconds
    Time since reference or first frame: 21.207952000 seconds
    Frame Number: 586
    Packet Length: 778 bytes
    Capture Length: 778 bytes
Ethernet II, Src: 00:08:02:62:30:5d, Dst: 00:d0:06:24:c8:0a
    Destination: 00:d0:06:24:c8:0a (160.39.192.1)
    Source: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
    Type: IP (0x0800)
Internet Protocol, Src Addr: 160.39.194.183 (160.39.194.183), Dst Addr: 147.135.4.128
(147.135.4.128)
    Version: 4
    Header length: 20 bytes
    Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
        0000 00.. = Differentiated Services Codepoint: Default (0x00)
        .... ..0. = ECN-Capable Transport (ECT): 0
        ....0 = ECN-CE: 0
    Total Length: 764
    Identification: 0xcd5e (52574)
    Flags: 0x00
        0... = Reserved bit: Not set
        .0.. = Don't fragment: Not set
        ..0. = More fragments: Not set
    Fragment offset: 0
    Time to live: 128
    Protocol: UDP (0x11)
    Header checksum: 0x6fac (correct)
    Source: 160.39.194.183 (160.39.194.183)
    Destination: 147.135.4.128 (147.135.4.128)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
    Source port: 5060 (5060)
    Destination port: 5060 (5060)
    Length: 744
    Checksum: 0x79bf (correct)
Session Initiation Protocol
    Status-Line: SIP/2.0 200 OK
        Status-Code: 200
        Resent Packet: False
    Message Header
        Content-Length: 224
        Contact: <sip:7185042154@160.39.194.183:5060>
        Call-ID: SD5oukc01-d2e552914b255026f158ce0c2a5ce75f-js19002
        Content-Type: application/sdp
        CSeq: 996798750 INVITE
        From: <sip:6102567675@147.135.4.129;user=phone;bvoice=ACME-
06t5tpji5ub7e>;tag=SD5oukc01-1051083302-1112242643515
            SIP from address: sip:6102567675@147.135.4.129
            SIP tag: SD5oukc01-1051083302-1112242643515
        To: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com;user=phone>;tag=16532169023379
            SIP Display info: "Raj Bakhru"

      SIP to address: sip:7185042154@sip.broadvoice.com
      SIP tag: 16532169023379
    Server: SJphone/1.50.271d (SJ Labs)
    Via: SIP/2.0/UDP 147.135.4.128:5060;branch=z9hG4bK2qi23s20a0t1b94gv001.1sr
Message body
   Session Description Protocol
     Session Description Protocol Version (v): 0
     Owner/Creator, Session Id (o): - 3321231442 3321231442 IN IP4 160.39.194.183
       Owner Username: -
       Session ID: 3321231442
       Session Version: 3321231442
       Owner Network Type: IN
       Owner Address Type: IP4
       Owner Address: 160.39.194.183
     Session Name (s): SJphone
     Connection Information (c): IN IP4 160.39.194.183
       Connection Network Type: IN
       Connection Address Type: IP4
       Connection Address: 160.39.194.183
     Time Description, active time (t): 0 0
       Session Start Time: 0
       Session Stop Time: 0
     Session Attribute (a): direction:actpass
       Session Attribute Fieldname: direction
       Session Attribute Value: actpass
     Media Description, name and address (m): audio 49154 RTP/AVP 0 101
       Media Type: audio
       Media Port: 49154
       Media Proto: RTP/AVP
       Media Format: ITU-T G.711 PCMU
       Media Format: 101
     Media Attribute (a): rtpmap:0 PCMU/8000
       Media Attribute Fieldname: rtpmap
       Media Attribute Value: 0 PCMU/8000
     Media Attribute (a): rtpmap:101 telephone-event/8000
       Media Attribute Fieldname: rtpmap
       Media Attribute Value: 101 telephone-event/8000
     Media Attribute (a): fmtp:101 0-11,16
       Media Attribute Fieldname: fmtp
       Media Attribute Value: 101 0-11,16

Packet #14 – ACK

No.   Time   Source   Destination   Protocol Info
  593 21.295445 147.135.4.128   160.39.194.183   SIP   Request: ACK
sip:7185042154@160.39.194.183:5060

Frame 593 (570 bytes on wire, 570 bytes captured)
   Arrival Time: Mar 30, 2005 23:17:24.157337000
   Time delta from previous packet: 0.087493000 seconds
   Time since reference or first frame: 21.295445000 seconds
   Frame Number: 593
   Packet Length: 570 bytes
   Capture Length: 570 bytes
Ethernet II, Src: 00:d0:06:24:c8:0a, Dst: 00:08:02:62:30:5d
   Destination: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
   Source: 00:d0:06:24:c8:0a (160.39.192.1)
   Type: IP (0x0800)
Internet Protocol, Src Addr: 147.135.4.128 (147.135.4.128), Dst Addr: 160.39.194.183
(160.39.194.183)
   Version: 4
   Header length: 20 bytes
   Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
      0000 00.. = Differentiated Services Codepoint: Default (0x00)
      .... ..0. = ECN-Capable Transport (ECT): 0
      ....0 = ECN-CE: 0
   Total Length: 556
   Identification: 0xd1b0 (53680)
   Flags: 0x00
   Fragment offset: 0
   Time to live: 50
   Protocol: UDP (0x11)
   Header checksum: 0xba2a (correct)
   Source: 147.135.4.128 (147.135.4.128)
   Destination: 160.39.194.183 (160.39.194.183)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
   Source port: 5060 (5060)
   Destination port: 5060 (5060)
   Length: 536
   Checksum: 0x76c2 (correct)
Session Initiation Protocol
   Request-Line: ACK sip:7185042154@160.39.194.183:5060 SIP/2.0
      Method: ACK
      Resent Packet: False
   Message Header
      Via: SIP/2.0/UDP 147.135.4.128:5060;branch=z9hG4bK2qi23t20cg2g09sor1k1.1sr
      From: <sip:6102567675@147.135.4.129;user=phone;bvoice=ACME-
06t5tpji5ub7e>;tag=SD5oukc01-1051083302-1112242643515
         SIP from address: sip:6102567675@147.135.4.129
         SIP tag: SD5oukc01-1051083302-1112242643515
      To: "Raj Bakhru"<sip:7185042154@sip.broadvoice.com;user=phone>;tag=16532169023379
         SIP Display info: "Raj Bakhru"
         SIP to address: sip:7185042154@sip.broadvoice.com
         SIP tag: 16532169023379
      Call-ID: SD5oukc01-d2e552914b255026f158ce0c2a5ce75f-js19002
      CSeq: 996798750 ACK
      Contact: <sip:6102567675@147.135.4.128:5060;bvoice=ACME-ntqjclfhfev2b;transport=udp>
      Max-Forwards: 69
      Content-Length: 0

Packet #15 – BYE

No.   Time   Source   Destination   Protocol Info
  3574 42.861581   160.39.194.183   147.135.4.128   S IP   Request: BYE
sip:6102567675@147.135.4.128:5060;transport=udp;bvoice=ACME-ntqjclfhfev2b;ep=147.135.4.129

Frame 3574 (626 bytes on wire, 626 bytes captured)
   Arrival Time: Mar 30, 2005 23:17:45.723473000
   Time delta from previous packet: 21.566136000 seconds
   Time since reference or first frame: 42.861581000 seconds
   Frame Number: 3574
   Packet Length: 626 bytes
   Capture Length: 626 bytes
Ethernet II, Src: 00:08:02:62:30:5d, Dst: 00:d0:06:24:c8:0a
   Destination: 00:d0:06:24:c8:0a (160.39.192.1)
   Source: 00:08:02:62:30:5d (CompaqCo_62:30:5d)
   Type: IP (0x0800)
Internet Protocol, Src Addr: 160.39.194.183 (160.39.194.183), Dst Addr: 147.135.4.128
(147.135.4.128)
   Version: 4
   Header length: 20 bytes
   Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
     0000 00.. = Differentiated Services Codepoint: Default (0x00)
     .... ..0. = ECN-Capable Transport (ECT): 0
     ....0 = ECN-CE: 0
   Total Length: 612
   Identification: 0xd1a5 (53669)
   Flags: 0x00
     0... = Reserved bit: Not set
     .0.. = Don't fragment: Not set
     ..0. = More fragments: Not set
   Fragment offset: 0
   Time to live: 128
   Protocol: UDP (0x11)
   Header checksum: 0x6bfd (correct)
   Source: 160.39.194.183 (160.39.194.183)
   Destination: 147.135.4.128 (147.135.4.128)
User Datagram Protocol, Src Port: 5060 (5060), Dst Port: 5060 (5060)
   Source port: 5060 (5060)
   Destination port: 5060 (5060)
   Length: 592
   Checksum: 0x38a6 (correct)
Session Initiation Protocol
   Request-Line: BYE sip:6102567675@147.135.4.128:5060;transport=udp;bvoice=ACME-
ntqjclfhfev2b;ep=147.135.4.129 SIP/2.0
     Method: BYE
     Resent Packet: False
   Message Header
     Content-Length: 0
     Contact: <sip:7185042154@160.39.194.183:5060>
     Call-ID: SD5oukc01-d2e552914b255026f158ce0c2a5ce75f-js19002
     Max-Forwards: 70
     CSeq: 1 BYE
     From: <sip:7185042154@sip.broadvoice.com;user=phone>;tag=16532169023379
      SIP from address: sip:7185042154@sip.broadvoice.com
      SIP tag: 16532169023379
     To: <sip:6102567675@147.135.4.129;user=phone;bvoice=ACME-
06t5tpji5ub7e>;tag=SD5oukc01-1051083302-1112242643515

SIP to address: sip:6102567675@147.135.4.129
SIP tag: SD5oukc01-1051083302-1112242643515
User-Agent: SJphone/1.50.271d (SJ Labs)
Via: SIP/2.0/UDP
160.39.194.183;rport;branch=z9hG4bKa027c2b70131c9b1424b79e900002ff600000014

Appendix B (System UCF)

```
#UCF FILE
net FPGA_CLK1 loc="p77";
net PB_LB_N loc="p140";
net PB_UB_N loc="p146";
net PB_WE_N loc="p123";
net PB_OE_N loc="p125";
net RAM_CE_N loc="p147";

net PB_A<0> loc="p83";
net PB_A<1> loc="p84";
net PB_A<2> loc="p86";
net PB_A<3> loc="p87";
net PB_A<4> loc="p88";
net PB_A<5> loc="p89";
net PB_A<6> loc="p93";
net PB_A<7> loc="p94";
net PB_A<8> loc="p100";
net PB_A<9> loc="p101";
net PB_A<10> loc="p102";
net PB_A<11> loc="p109";
net PB_A<12> loc="p110";
net PB_A<13> loc="p111";
net PB_A<14> loc="p112";
net PB_A<15> loc="p113";
net PB_A<16> loc="p114";
net PB_A<17> loc="p115";
net PB_A<18> loc="p121";
net PB_A<19> loc="p122";

net PB_D<0> loc="p153";
net PB_D<1> loc="p145";
net PB_D<2> loc="p141";
net PB_D<3> loc="p135";
net PB_D<4> loc="p126";
net PB_D<5> loc="p120";
net PB_D<6> loc="p116";
net PB_D<7> loc="p108";
net PB_D<8> loc="p127";
net PB_D<9> loc="p129";
net PB_D<10> loc="p132";
net PB_D<11> loc="p133";
net PB_D<12> loc="p134";
net PB_D<13> loc="p136";
net PB_D<14> loc="p138";
net PB_D<15> loc="p139";

net ETHERNET_CS_N loc="p82";
net ETHERNET_IOCS16_N loc="p74";
net ETHERNET_RDY loc="p81";
net ETHERNER_IREQ loc="p75";

net AU_SDTO0 loc="p173";
net AU_SDTI loc="p169";
net AU_LRCK loc="p168";
net AU_MCLK loc="p167";
net AU_BCLK loc="p166";
net AU_CSN loc="p165";          #lower 3 data for PB are also audio codec configuration bits
```