THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Lecture Qt011 Networking

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Outline

- Overview
- UDP Communication
  - Hands-On Example: UDP and **QDataStream**
  - Hands-On Example: UDP and **QTextStream**
- TCP Client-Server Applications
  - Hands-On Example: TCP and **QDataStream**
- Key Points

QtNetwork Module

- **QtNetwork** module provides support for
  - UDP sockets
  - TCP servers/sockets
  - SSL sockets (inherits from TCP)
  - FTP protocol
  - HTTP protocol
- See module description in Qt Assistant for additional details

QtNetwork Module

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- Check your project file (**.pro**) before you attempt to compile
- You will need to add the following line if it is missing

```
QT    +=  network
```

UDP User Datagram Protocol

- Low-overhead protocol
- No “connection”
- Not for applications where reliability is required since packet delivery is not guaranteed
  - Packets may arrive out-of-order
  - Duplicate packets may be received
  - Packets may not arrive at all
- Typical uses of UDP
  - Streaming media
  - VoIP
  - Real-time multiplayer gaming

Example: UDP/QDataStream

- **Sender** Application
  - **QLineEdit** widget allows user to input a text message
  - Send button forwards message to Receiver application via UDP and clears sent message from **QLineEdit** widget
  - Quit button terminates Sender application
  - Uses **QDataStream** abstraction object
- **Receiver** Application
  - **QLabel** widget initially displays "***Ready to Receive***"
  - Each incoming UDP message replaces previously displayed text in the **QLabel** widget

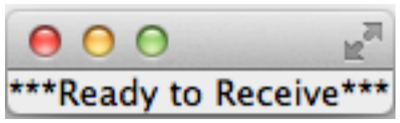
Example: UDP/QDataStream

```
// main.cpp  -- Receiver
#include <QApplication>
#include "udplabel.h”

int main(int argc, char* argv[])
{
   QApplication myapp(argc, argv);

   UDPLabel  myUDPLabel("***Ready to Receive***");
   myUDPLabel.show();

   return myapp.exec();
}
```


Ready to Receive

Example: UDP/QDataStream

```
// udplabel.h - Receiver

#ifndef UDPLABEL_H
#define UDPLABEL_H

#include <QLabel>
#include <QUdpSocket>

class UDPLabel : public QLabel
{
 Q_OBJECT;

public:
 UDPLabel(QString msg);

private:
 QUdpSocket *myUDPSocket;

private slots:
 void processPendingDatagrams();
};

#endif
```

Example: UDP/QDataStream

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```
// udplabel.cpp -- Receiver

#include <QtGui>
#include "udplabel.h"
#include <QString>
#include <QByteArray>
#include <QDataStream>

UDPLabel::UDPLabel(QString msg) : QLabel(msg)
{
  myUDPSocket = new QUdpSocket(this);

  myUDPSocket->bind(5678);

  connect( myUDPSocket, SIGNAL(readyRead()),
           this, SLOT(processPendingDatagrams()) );
}
```

Example: UDP/QDataStream

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```
// udplabel.cpp -- Receiver continued

void UDPLabel::processPendingDatagrams()
{
  QByteArray mydatagram;

  while ( myUDPSocket->hasPendingDatagrams() )
  {
    mydatagram.resize(myUDPSocket->pendingDatagramSize());
    myUDPSocket->readDatagram(mydatagram.data(), mydatagram.size());
  }

  QString msg;
  QDataStream in(&mydatagram, QIODevice::ReadOnly);

  in.setVersion(QDataStream::Qt_4_4);

  in >> msg;
  this->setText(msg);
}
```

Example: UDP/QDataStream

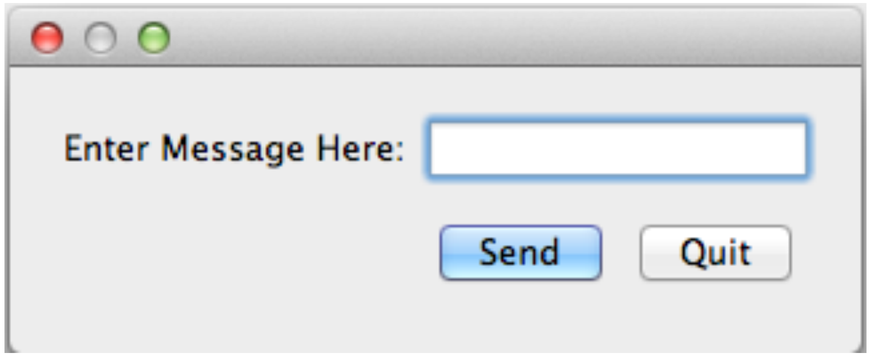
```
// main.cpp -- Sender

#include <QApplication>
#include "senderdialog.h"

int main(int argc, char* argv[])
{
  QApplication myapp(argc, argv);

  SenderDialog mysender;
  mysender.show();

  return myapp.exec();
}
```



Example: UDP/QDataStream

```
// senderdialog.h - Sender

#ifndef SENDERDIALOG_H
#define SENDERDIALOG_H

#include <QDialog>
#include <QLineEdit>
#include <QPushButton>
#include <QUdpSocket>
#include <QLabel>
#include <QHBoxLayout>
#include <QVBoxLayout>
```

```
class SenderDialog : public QDialog
{
  Q_OBJECT

public:
  SenderDialog(QWidget *parent = 0);

private:
  QLabel* label;
  QLineEdit* lineEdit;
  QPushButton* sendButton;
  QPushButton* quitButton;

  QVBoxLayout* mainLayout;
  QHBoxLayout* editLayout;
  QHBoxLayout* buttonLayout;

  QUdpSocket* sendSocket;

private slots:
  void writeMessage();
};
#endif
```

Example: UDP/QDataStream

```
// senderdialog.cpp

#include "senderdialog.h"
#include <QUdpSocket>
#include "senderdialog.h"

SenderDialog::SenderDialog(QWidget* parent) : QDialog(parent)
{
  label = new QLabel("Enter Message Here:");
  lineEdit = new QLineEdit;
  sendButton = new QPushButton("&Send");
  quitButton = new QPushButton("&Quit");
  mainLayout = new QVBoxLayout(this);
  editLayout = new QHBoxLayout;
  buttonLayout = new QHBoxLayout;

  mainLayout->addLayout(editLayout);
  mainLayout->addStretch();
  mainLayout->addLayout(buttonLayout);
  editLayout->addWidget(label);
  editLayout->addWidget(lineEdit);
  buttonLayout->addStretch();
  buttonLayout->addWidget(sendButton);
  buttonLayout->addWidget(quitButton);

  connect(sendButton, SIGNAL(clicked()), this, SLOT(writeMessage()));
  connect(quitButton, SIGNAL(clicked()), this, SLOT(close()));

  sendSocket = new QUdpSocket;
}
```

Example: UDP/QDataStream

```
// senderdialog.cpp -- continued

void SenderDialog::writeMessage()
{
  QByteArray datagram;

  QDataStream out(&datagram, QIODevice::WriteOnly);
  out.setVersion(QDataStream::Qt_4_4);

  QString msg = lineEdit->text();
  lineEdit->setText("");

  out << msg;

  sendSocket->writeDatagram(datagram, QHostAddress::LocalHost, 5678);
}
```

Example: UDP/QTextStream

```
// senderdialog.cpp

…

void SenderDialog::writeMessage()
{
  QByteArray  datagram;
  QTextStream out(&datagram, QIODevice::WriteOnly);

  QString msg = lineEdit->text();
  lineEdit->setText("");

  out << msg << endl;

  sendSocket->writeDatagram(datagram, QHostAddress::LocalHost, 5678);
}
```

Minor changes to one method

Example: UDP/QTextStream

```
// udplabel.cpp -- Receiver
…

void UDPLabel::processPendingDatagrams()
{
  QByteArray mydatagram;

  while (myUDPSocket->hasPendingDatagrams())
  {
    mydatagram.resize(myUDPSocket->pendingDatagramSize());
    myUDPSocket->readDatagram(mydatagram.data(), mydatagram.size());
  }

  QString msg;
  QTextStream in(&mydatagram, QIODevice::ReadOnly);

  in >> msg;

  this->setText(msg);
}
```

Minor changes to one method

Lessons Learned

- **QTextStream** interface objects may be used for either **UDP** or **TCP** communications with only minor changes to the send/receive code that utilizes **QDataStream** objects

TCP Transmission Control Protocol

- Stream-oriented protocol
- One of the core internet protocols
- Unlike UDP
  - TCP is connection oriented
    - Connection must be established
    - Data transferred
    - Connection terminated
  - TCP provides reliable delivery
    - Handles duplicate, lost, and out-of-order packets
- Typical uses of TCP
  - File transfer, email

Server Applications

- Server applications typically run invisibly in the background
  - Don't require a GUI
- Save memory and disk space by avoiding linking with GUI classes
  - Use **QCoreApplication** object in **main()** instead of **QApplication** object
  - Add **QT -= qui** to project file

QTcpServer

- Class allows your application to listen for an incoming TCP connection
  - The server can listen to a particular port or any port using **listen()**
  - It can also listen for a specific machine address or any address
  - Methods **serverAddress()** and **serverPort()** identify particular address and port
  - **close()** will terminate listening
- Typically used with an event loop but can block using **waitForNewConnection()**
  - Can specify timeout interval

QTcpServer

- **nextPendingConnection()**
  - Returns next connection as a pointer to a **QTcpSocket** object
- **newConnection()**
  - This ***signal*** is emitted when a client connects to the server
- **isListening()**
  - Returns true if currently listening; false otherwise
- **hasPendingConnections()**
  - Returns true if there are connections pending; false otherwise

QTcpSocket

- **connectToHost()** allows one to establish a connection to a particular host using
  - **QHostAddress** object
  - **QString** representation of an IP address or host name (lookup will be performed)
- **disconnectFromHost()**
  - Attempts to close socket; waits for any pending data to be written

QTcpSocket

- **connected()**
  - Signal emitted after **connectedToHost()** has been called and a connection has been successfully established
- **disconnected()**
  - This signal is emitted when the socket has been disconnected
- **readyRead()**
  - Signal emitted once every time new data is available for reading from the device.
  - Only emitted again once new data is available
- **error()**
  - Emitted after error occurs
  - Includes error description

Example: TCP/QDataStream

```
// TCP Example -- Greeting Server Application, main.cpp

#include <QCoreApplication>
#include <QtDebug>
#include "greetingserver.h"

int main(int argc, char* argv[])
{
  QCoreApplication myApp(argc, argv);

  GreetingServer server;
  qDebug() << "Server running";

  return myApp.exec();
} // End main()
```

Example: TCP/QDataStream

```
// TCP Example -- Greeting Server Application, greetingserver.h

#ifndef GREETINGSERVER_H
#define GREETINGSERVER_H

#include <QTcpServer>

class GreetingServer : public QTcpServer
{
  Q_OBJECT

public:
  GreetingServer(QObject* parent = 0);

private:
  QString  greetings[4];

private slots:
  void sendGreeting();
};

#endif
```

Example: TCP/QDataStream

```
// TCP Example -- Greeting Server Application, greetingserver.cpp

#include <QtNetwork>
#include "greetingserver.h”

GreetingServer::GreetingServer(QObject* parent) : QTcpServer(parent)
{
  greetings[0] = "Hello";                         // Initialize greetings array
  greetings[1] = "Howdy";
  greetings[2] = "Salutations";
  greetings[3] = "Aloha";

  // Initialize random number generator to number of seconds
  // between 00:00:00 and now
  qsrand(QTime(0,0,0).secsTo(QTime::currentTime()));

  // Send greeting upon new connection
  connect(this, SIGNAL(newConnection()), this, SLOT(sendGreeting()));

  // Listen for incoming connects on port 1234 of this machine
  this->listen(QHostAddress::LocalHost, 1234);
} // End GreetingServer::GreetingServer()
```

Example: TCP/QDataStream

```
// TCP Example -- Greeting Server Application, greetingserver.cpp - continued


void GreetingServer::sendGreeting()
{
  // Socket created as child of GreetingServer object
  QTcpSocket* client = this->nextPendingConnection();

  QByteArray block;
  QDataStream outgoingMessage(&block, QIODevice::WriteOnly);

  outgoingMessage.setVersion(QDataStream::Qt_4_1);

  // Select random greeting
  outgoingMessage << greetings[qrand() % 4];

  // Write greeting to socket
  client->write(block);

  // Attempt to close socket but wait until pending data written
  client->disconnectFromHost();
} // End GreetingServer::sendGreeting()
```

Example: TCP/QDataStream

```
// TCP Example -- Client, main.cpp

#include <QApplication>
#include "client.h"

int main(int argc, char* argv[])
{
  QApplication  myApp(argc, argv);

  Client  c;
  c.show();

  return myApp.exec();
} // End main()
```

Example: TCP/QDataStream

```
// client.h

#ifndef CLIENT_H
#define CLIENT_H
#include <QDialog>
#include <QPushButton>
#include <QLabel>
#include <QTcpSocket>
#include <QVBoxLayout>

class Client : public QDialog
{
  Q_OBJECT
public:
  Client(QWidget* parent = 0);
private:
  QTcpSocket*   socket;
  QLabel*       label;
  QPushButton*  button;
  QVBoxLayout*  mainLayout;
private slots:
  void updateLabel();
  void requestGreeting();
};

#endif
```

Example: TCP/QDataStream

```
// TCP Example -- Client, main.cpp

#include "client.h"
#include <QtNetwork>

Client::Client(QWidget* parent) : QDialog(parent)
{
  mainLayout = new QVBoxLayout(this);
  label = new QLabel("*** Ready ***");
  button = new QPushButton("Greet Me");
  mainLayout->addWidget(label);
  mainLayout->addStretch();
  mainLayout->addWidget(button);

  connect(button, SIGNAL(clicked()), this, SLOT(requestGreeting()));
} // End Client::Client()
```

Example: TCP/QDataStream

```
// TCP Example -- Client, main.cpp - continued

void Client::requestGreeting()
{
  socket = new QTcpSocket(this);
  connect(socket, SIGNAL(readyRead()), this, SLOT(updateLabel()));
  connect(socket, SIGNAL(disconnected()), socket, SLOT(deleteLater()));

  socket->connectToHost(QHostAddress::LocalHost, 1234);
} // End Client::requestGreeting()

void Client::updateLabel()
{
  QDataStream  incomingMessage(socket);
  incomingMessage.setVersion(QDataStream::Qt_4_1);

  QString msg;
  incomingMessage >> msg;
  label->setText(msg);

  delete socket;
} // End Client::updateLabel()
```

Observations

- The previous approach works for a small number of incoming connections
- To handle a large number of connections, create a separate thread for each connection

Key Points

- **QTcpSocket**/**QTcpServer** and **QUdpSocket** networking classes may be used to interface your Qt program with applications running locally or running on remote systems
  - Option One:
    - Declare, configure, and employ objects of these types
  - Option Two:
    - Derive customized versions of the types
    - Employ objects of your derived class types