# Next Gen Platform: Team & Mentor Guide

## 1 Introduction

For the 2015-2016 season, the *FIRST* Tech Challenge (FTC) will be adopting a new controller for its robot competitions. The new platform, which will replace the soon-to-be-discontinued LEGO Mindstorms NXT platform, uses an Android device, powered by a QualComm Snapdragon processor, as the primary robot controller. This document provides basic information about the new platform.

Please note that the contents of this document are subject to change.

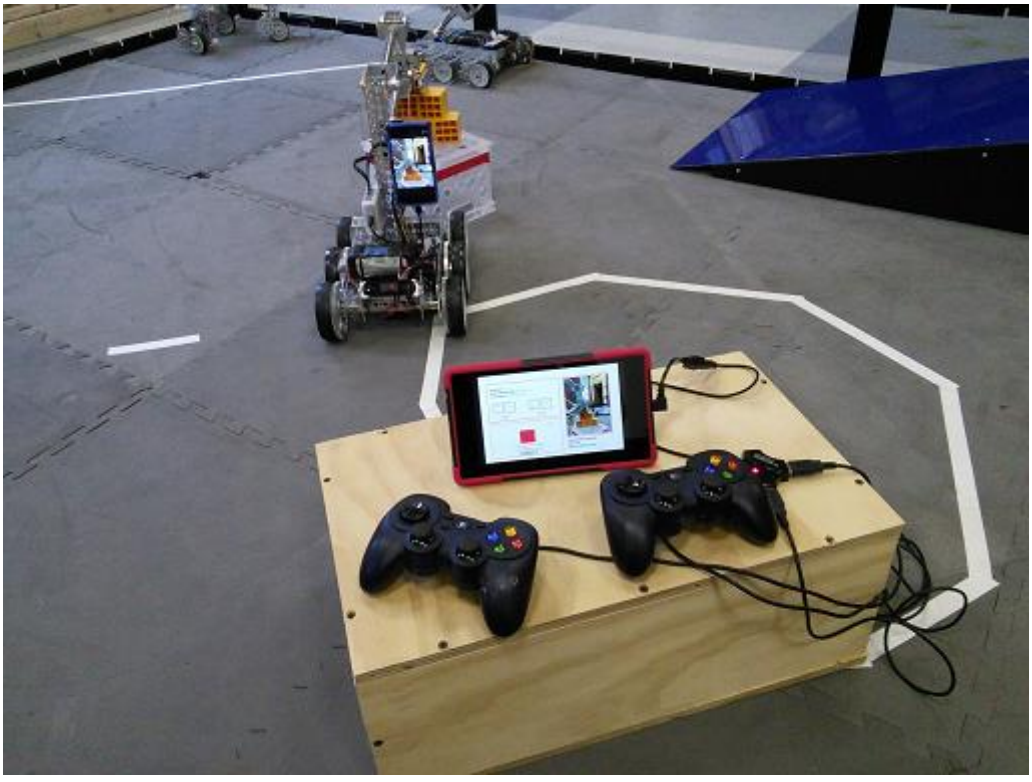

Figure 1 - FTC's new Android-based platform[1]

[1] Note that the user interfaces that are pictured on the Android devices are simulated and do not reflect the current user interfaces that are available with the new platform.

# 2 About Android

Android is Google's operating system that is used on smartphones, tablets, and other devices (wearables, GPS satnav systems, etc.). According to Google, there are over 1 billion active monthly Android users.[2] The number of Android devices that are sold exceeds the combined number of all Windows, iOS and MacOS devices sold.[3] Android is the world's most popular operating system.

Figure 2 - Android is the world's most popular computing platform.[4]

# 3 About the QualComm Snapdragon Processor

The Android devices that will be used for the FTC competitions will be equipped with a QualComm Snapdragon processor. Snapdragon is QualComm's family of advanced mobility processors. Snapdragon processors are used in over 1 billion devices worldwide.[5] Snapdragon processors are powerful, yet highly energy efficient. These processors provide vast computational power and have integrated graphics processing units (GPUs) that help render high definition video and 3D graphics, while consuming a minimum of electricity. Snapdragon processors also include integrated, power-efficient components used for wireless communication, navigation, gaming, and for other key functions.


Figure 3 - The Samsung Galaxy S5® is one of many Snapdragon-powered Android devices available.[6]

[2] http://www.techspot.com/news/57228-google-shows-off-new-version-of-android-announces-1-billion-active-monthly-users.html - Retrieved December 3, 2014.
[3] http://www.businessinsider.com/androids-share-of-the-computing-market-2014-3 - Retrieved December 3, 2014.
[4] Image from http://en.wikipedia.org/wiki/File:Android_robot.svg – Retrieved December 4, 2014.
[5] https://www.qualcomm.com/products/snapdragon - Retrieved December 3, 2014.
[6] Image from http://www.samsung.com/us/mobile/cell-phones/SM-G900VZKAVZW - Retrieved December 4, 2014.

# 4 Point-to-Point Wireless Connectivity

The new FTC platform is a solution that is based on the Android operating system. The new platform is a *point-to-point* solution. This means that teams will use two Android devices to control their robot. The first device will be mounted on the robot and act as the *robot controller*. The second device will reside with the team drivers and will be connected to a pair of gamepad controllers. This second device is known as the *driver station*. The driver station will communicate wirelessly with the robot controller.


Figure 4 - The new FTC platform is a point-to-point solution

The point-to-point communication model has the advantage that it is easier for an event manager to host an FTC competition. The event manager will no longer need to setup and support a wireless field control system at a competition. Instead, teams will bring their own driver stations and gamepads and control their robots using their own equipment.

Because the new platform utilizes a point-to-point communication system, a sports start procedure will be used to start and stop matches during the 2015-2016 season. With this sports start procedure, the referee will blow a whistle to start or stop the autonomous and tele-op phases of a match. Note that this will not be the first time FTC has used a sports start procedure for its matches. The FTC game Hot Shot! (2009) utilized a sport start procedure to start and stop the matches.

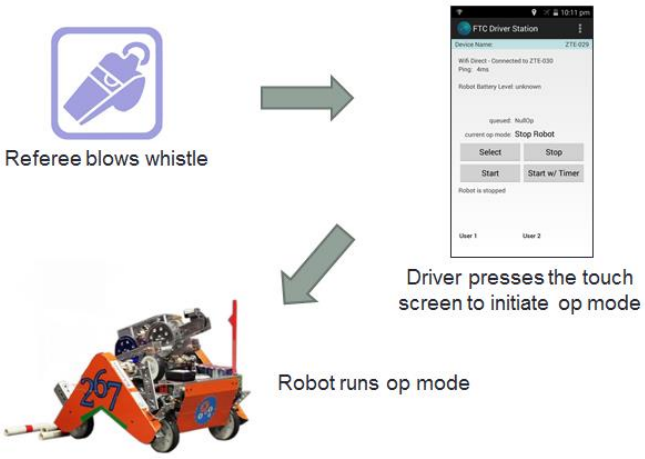


Figure 5 - A sports start procedure will be adopted.

# 5 New Hardware Modules

A series of new hardware modules have been developed to allow an Android robot controller to communicate with the devices (motors, servos, sensors, etc.) that are needed for a typical FTC robot.

## 5.1 Legacy Module

The new Android control platform is able to connect to, and communicate with, legacy NXT-compatible devices such as DC motor controllers, servo controllers and sensors. A new electronics module, known as the *Legacy Module* (or LM), can be used to connect a standard Android phone or tablet to NXT-compatible motor controllers, servo controllers and sensors. The Android device connects to the Legacy Module via a USB cable. The Legacy Module has six (6) NXT-style connector ports.

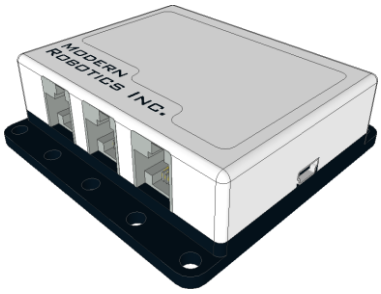


Figure 6 - Legacy Module has USB port for Android (see right side of case) and has six NXT ports for legacy devices

## 5.2 High Speed USB-Enabled DC Motor Controller

A new high speed, USB-enabled DC motor controller will be available with the new platform. The new USB-enabled DC motor controller is similar to the 12V motor controller that was included with the older Tetrix kit of parts. However, this new motor controller has some improved features:

- Screw terminals have been replaced with Anderson Power Pole connectors
- Communication with the device is made via a high speed USB connection
- The power circuit is optically isolated from the logic circuit to prevent ground loop issues

The new DC motor controller connects to an Android device with a USB cable. The device connects to a 12V DC input source and can drive two 12V DC motors independently. There is an encoder channel available for each motor output.

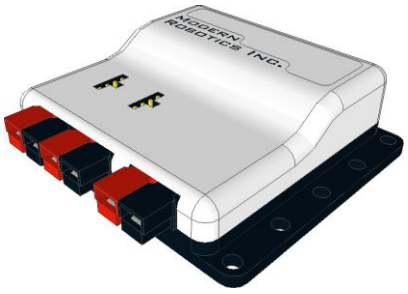


Figure 7 - New Motor Controller has two DC motor channels and uses Anderson Power Pole connectors

## 5.3 High Speed USB-Enabled Servo Controller

A new high-speed, USB-enabled servo controller will be available with the new platform. The new USB-enabled servo controller is similar to the servo motor controller that was included with the older Tetrix kit of parts. However, this new servo controller has some improved features:

- Screw terminals for the 12V DC input have been replaced with Anderson Power Pole connectors
- Communication with the device is made via a high speed USB connection
- The power circuit is optically isolated from the logic circuit to prevent ground loop issues

The new servo controller connects to an Android device with a USB cable. The device connects to a 12V DC input source and can drive six servo motors independently.

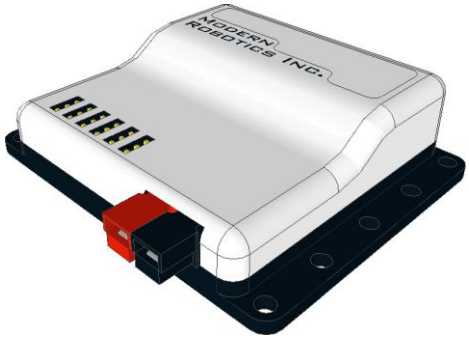


Figure 8 – New servo controller is USB-enabled and uses Anderson Power pole connectors

## 5.4 Power Module with Integrated USB Hub

A new module, known as the Power Module, has been introduced with the new platform. The Power Module accepts a 12V DC input from a rechargeable battery as its power source. It has Anderson Power Pole connectors to provide 12V Power to the DC Motor and Servo controllers.

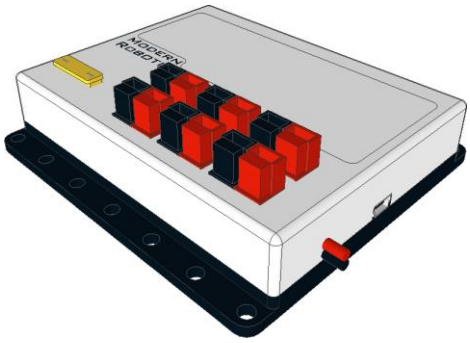

Figure 9 - Power Module accepts 12V DC input and distributes 12V power to motor and servo controllers

The Power Module is equipped with a manual on/off switch, which can be used as the primary power switch for a robot. The Power Module also has a replaceable safety fuse to guard against high current situations.

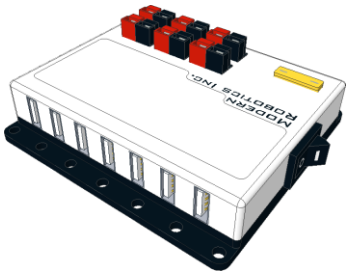

Figure 10 - Power Module also has a manual on/off switch and a replaceable safety fuse

In addition to providing 12V power to the motor and servo controllers, the Power Module was designed to provide USB connectivity for the new platform. An Android phone will connect to the Power Module's integrated USB hub through a USB Mini style port (visible on the right side of Figure 9). Devices such as the Legacy Module, the USB-enabled DC Moto Controller and the USB-enabled Servo Controller will connect to the type A USB ports (see Figure 10 and Figure 11). The Power Module's integrated USB hub will provide power to the connected devices (except for the Android phone, which acts as a USB host device). The Android phone will be able to communicate with multiple devices through the Power Module's integrated USB hub.

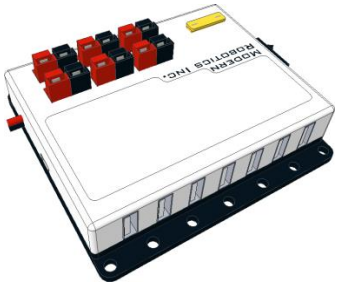

Figure 11 - The Power Module has an integrated 7-port USB hub

## 5.5 Advanced Sensor Module

Another module, known as the Advanced Sensor Module, will also be available with the new platform. The Advanced Sensor Module will communicate with an Android device through a high-speed USB connection. The Advanced Sensor Module will provide multiple analog and digital input/output ports. The Advanced Sensor Module will have 8 digital I/O ports, 8 analog input ports, 2 analog output ports, 2 PWM output ports, and six high-speed $I^2C$ ports.

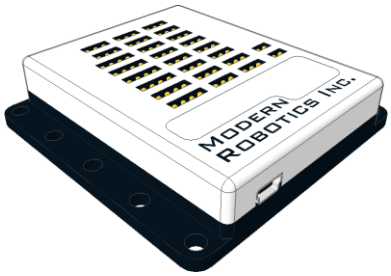


Figure 12 - The Advanced Sensor Module will provide a variety of input/output ports for the new platform

Modern Robotics will be introducing a new line of sensors that are designed to operate with the new Advanced Sensor Module.

Figure 13 - A new set of sensors will be available for the ASM.

# 6 Example Robot Configurations

## 6.1 Support for Legacy Hardware

Unfortunately, for the 2015-2016, the LEGO Mindstorms NXT device will not be allowed in FTC competitions. However, teams who have legacy NXT-compatible DC motor controllers, servo controllers, and sensors can still use these devices for the 2015-2016 season. The Legacy Module acts as a "bridge" between the Android robot controller and the legacy NXT-compatible devices.

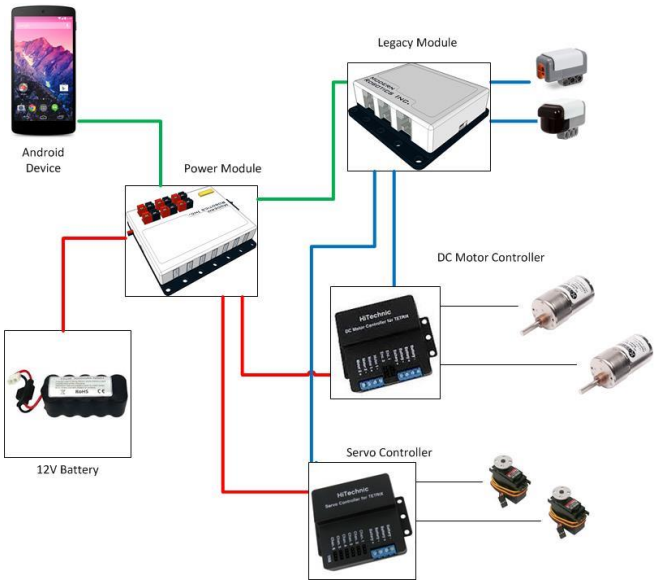


Figure 14 – Example configuration with legacy Tetrix motor & servo controllers.

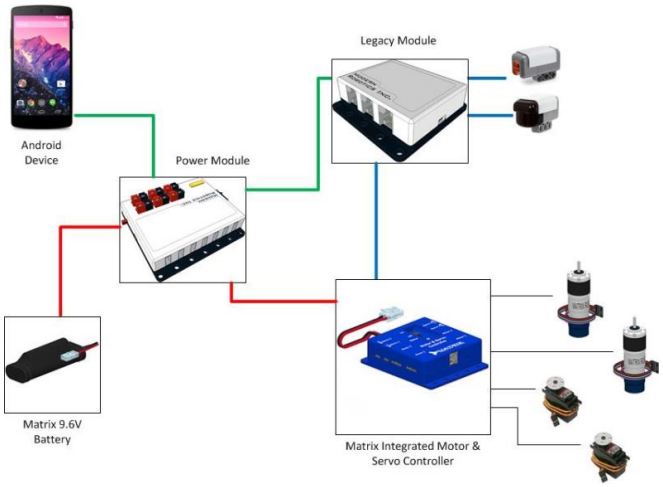


Figure 15 – Example configuration with a Matrix legacy motor/servo controller.[7]

[7] Note that support for the legacy Matrix 9.6V Motor/Servo controller is not yet available with the FTC sdk, but it is scheduled to be available late summer 2015.

## 6.2 USB-Enabled Hardware

Teams can also elect to use the new USB-enabled devices (DC motor controller, servo controller and advanced sensor module). The new USB-enabled devices have the benefit of utilizing a much faster communication bus than the older NXT-compatible devices.

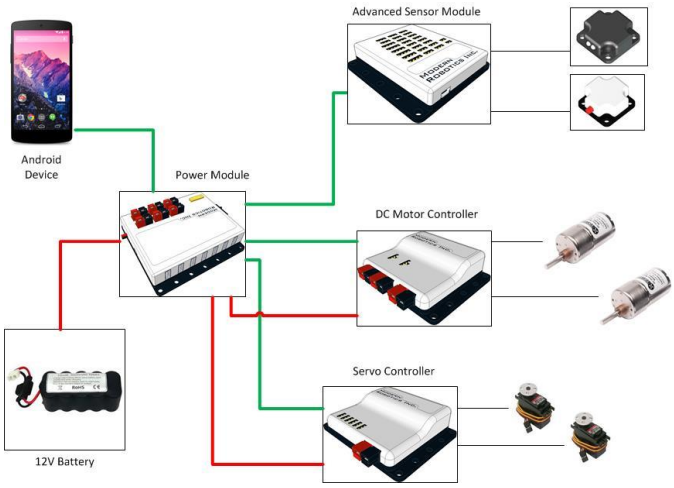


Figure 16 – Example configuration with new USB-enabled devices.

Note that it is also possible to use a combination of new (USB-enabled) and legacy (NXT-compatible) devices on a single robot.

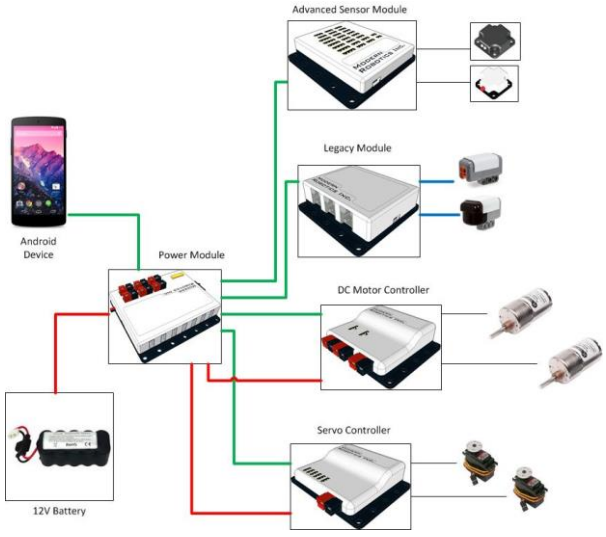


Figure 17 – Example configuration with new and legacy devices.

# 7 Android Device

## 7.1 ZTE Speed

For the 2015-2016, the ZTE Speed is the recommended Android device for the FTC competition program. The ZTE Speed that is available through the FTC "storefront" (available through TIMS) is the same device that is sold commercially at retail outlets like Best Buy and online at vendors such as Amazon. The ZTE Speed will be used as the robot controller and the driver station.


Figure 18 - The ZTE Speed is the recommended Android device.

The ZTE Speed has the following features:

- QualComm Snapdragon 410 Processor
- Android 4.4 (Kit Kat)
- Micro USB OTG Port
- 4.5" Touchscreen
- 5MP rear camera, 2MP front camera
- 2000 mAh battery
- Supports WiFi Direct channel changing

## 7.2 Alternate Android Devices

The ZTE Speed is the recommended Android device for the FTC program. It has been carefully tested with the FTC software and hardware and has performed well. Unfortunately, the ZTE Speed is not available in all regions. If you are in a region where the ZTE Speed is unavailable, then you will need to find an alternate Android device that will work with the FTC hardware and software.

In most regions outside of the US, the Motorola Moto G (Kit Kat) is available for international teams to use for FTC.

In order for an Android device to work with the FTC hardware and software it should meet the following minimum requirements[8]:

- QualComm Snapdragon Processor
- Android Kit Kat 4.4 (Lollipop is not yet supported)
- USB Micro On-the-Go (OTG) port (device needs to act as a USB host and client)
- Support for WiFi Direct
- 802.11 b/g/n at a minimum (2.4GHz band)
    - 802.11a/b/g/n is also allowed (2.4GHz and 5GHz bands)
- Support for PC Xbox-compatible gamepad including Logitech F310
- Minimum 1GB RAM, 2GB preferable

Note that even if an Android device satisfies the minimum requirements listed above, it still might not work properly. If you are considering using a device for FTC competition, you will need to test it carefully to verify that it functions properly with the FTC hardware and software.

Also note that not every Android device will support WiFi Direct channel changing. WiFi Direct Channel changing requires special permissions to be able to modify a wireless configuration file on the phone. The ZTE Speed has a special app from ZTE that allows for channel changing. Other phones might not allow WiFi Direct Channel changing. If a phone does not allow WiFi Direct channel changing, then the team that is using the device will be stuck using their device's default WiFi Direct channel at an event. It is helpful to have the ability to change the channel in case there is wireless interference on a certain channel.

# 8 Development Environment

LabVIEW and RobotC are not currently available for the new robot controller platform. Instead, teams will use Java-based tools to create and modify programs.

[8] Note that FIRST is working with our international partners to find a suitable alternate Android device for regions where the ZTE Speed is unavailable. If you are unable to get a ZTE speed in your region, contact your local FTC partner for a recommendation on an alternate device that is available locally within your region.

## 8.1 Robot Control Model

With the new Android platform, teams will use Android apps to control their robots for both autonomous and driver-controlled phases of a match. The new Android platform uses a point-to-point control model. Each team will use one Android device as a *driver station* and another device as a *robot controller*.

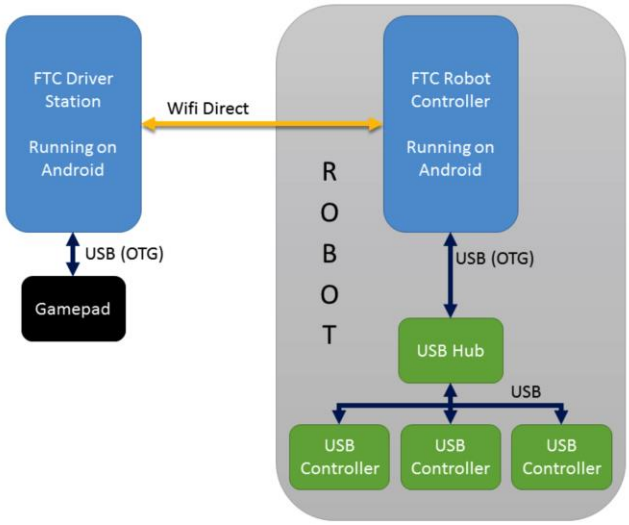


Figure 19 - Driver Station communicates with Robot Controller using WiFi Direct

### 8.1.1 Driver Station App

The driver station will have two gamepads connected to the Android device and will run a special *FIRST*-provided driver station app to communicate with the robot controller. The driver station can be used to start and stop program runs, drive the robot (in driver-controlled mode) and view status and feedback information from the robot through the touch screen display.

### 8.1.2 Robot Controller App

The robot controller is the Android device that is mounted on the frame of the robot. It will run a special robot controller Android app that will be used to communicate with the driver station and to control the motor/servo controllers and sensors on the robot. The robot controller app will be modified by the teams to create their custom autonomous and driver-controlled programs.

Teams will need to create “operational modes” or “op modes” for the robot controller app. Op modes are program modules that can be selected by a driver during a match to run during the autonomous or driver-controlled portion of the match. A team might have one or more op mode modules that they can use to run a set of autonomous tasks. A team might also have one or more op mode modules that they can use for driver-controlled operation of their robot. The driver station app lets a team select which op mode to execute during a particular phase of a match.

## 8.2 Java Development

The new Android platform uses the Java programming language to create/modify apps for the robot controller. Teams will have the option of using a text-based programming tool called Android Studio, or a visual design programming tool called App Inventor.

### 8.2.1 Android Studio

Android Studio is available for free from the Google Android developer website. It is an integrated development environment (IDE) and it runs on Mac, Windows and Linux. Android Studio is the tool that many professional developers use to create apps for the Android platform. Teams who choose to use the Android Studio IDE will also use a *software development kit* (SDK) that was developed by QualComm, to build op mode for their robot.

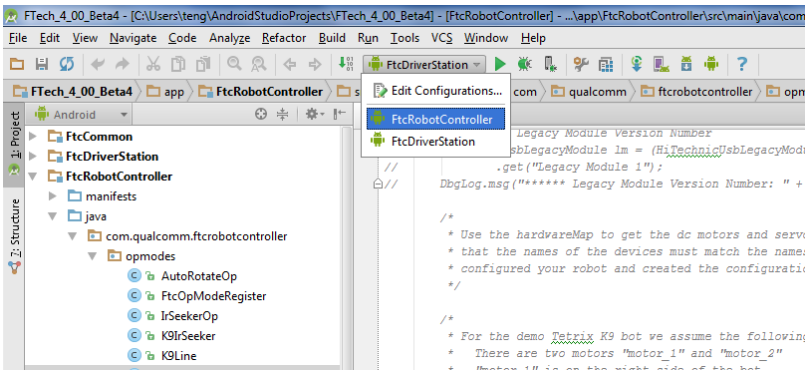


Figure 20 - Android Studio is a text-based programming tool.

### 8.2.2 The App Inventor

The App Inventor is a Cloud-based visual design tool that is used to create Android apps. A special set of components were created by an engineer from Google to extend the App Inventor so that it can be used to create custom op modes for an FTC robot. The App Inventor is a visual design tool that makes it easy to build an app, by simply using a Javascript-enabled web browser.

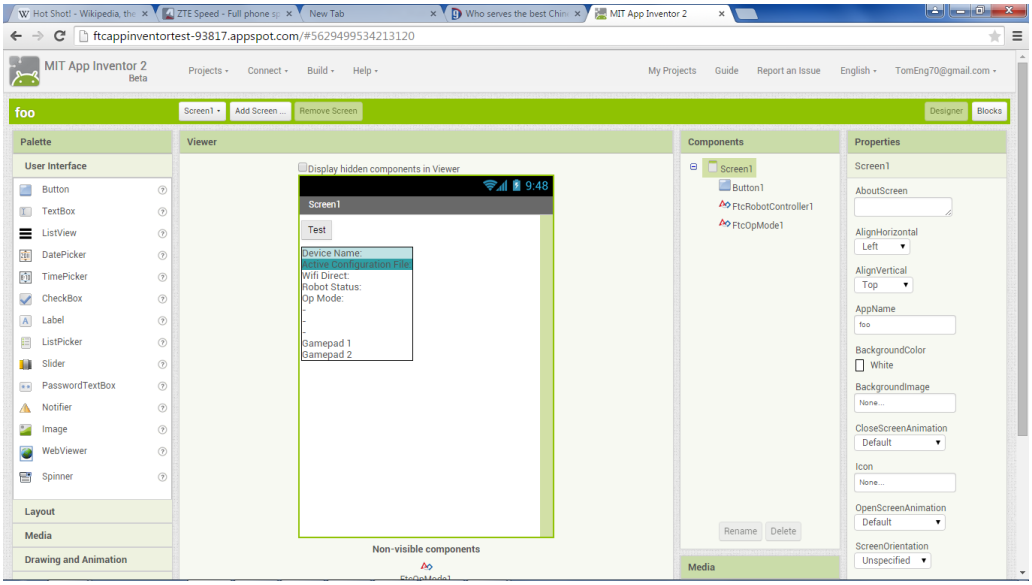


Figure 21 - App Inventor allows for visual design of the app.

The App Inventor includes a drag and drop "what you see is what you get" (WYSIWYG) design tool for creating an app. There is a special palette of additional App Inventor components that can be used to create custom op modes for an FTC robot. The App Inventor also has Blockly-style editor that is used to create the programming logic for an app.

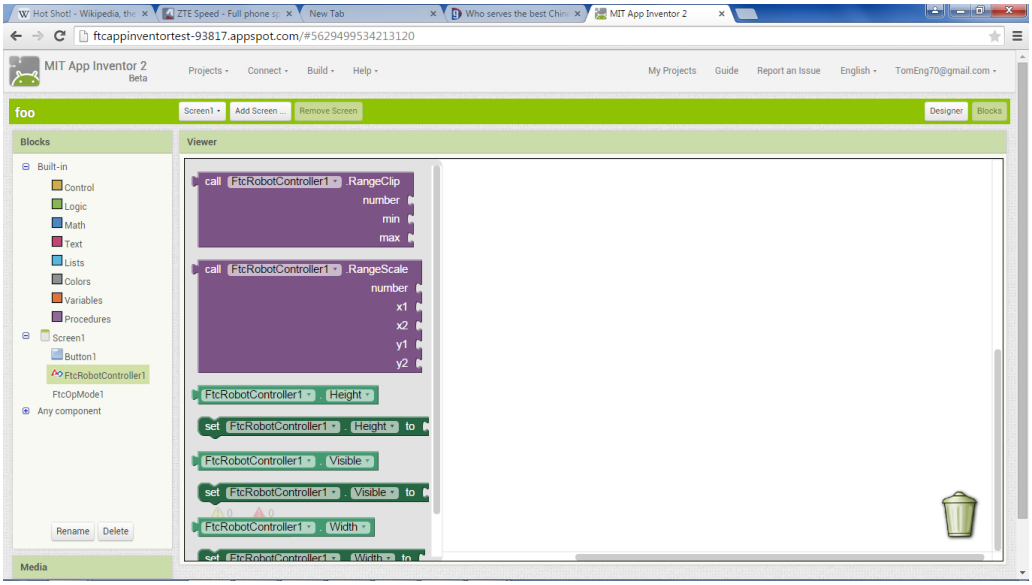


Figure 22 - App Inventor uses Blockly style elements to program the logic behind an app.

Normally the App Inventor is a Cloud-based application that is run on an MIT server. However, to meet the demands of our competition, FTC has developed a method to run the App Inventor locally on a laptop. Teams can use this locally installed version of the App Inventor to write their programs on their laptops, even at events where they might not have access to the Internet.

# 9 Getting Additional Information

If you have questions regarding the new platform, please visit the FTC Technology forum:

http://ftcforum.usfirst.org/forumdisplay.php?156-FTC-Technology