



5G Communication System And Analysis Tool Design Based On MATLAB

Hengnian Zhu, Nokia Shanghai Bell

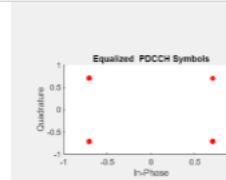


MATLAB EXPO

Abstract

- Develop 5G downlink transceiver algorithms using MATLAB
- Develop Web App for 5G downlink baseband data analysis using MATLAB App Designer
- Deploy Web App using MATLAB Web App Server

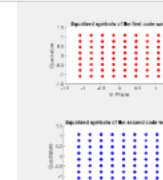
MATLAB Web App Server



LtePdcchAnalyzer
by Zhu Hengnian

LTE PDCCH Analyzer for Single SubFrame

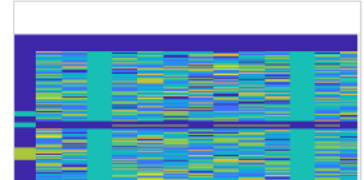
version 1.11



LtePdschAnalyzer
by Zhu Hengnian

LTE PDSCH Analyzer for Single SubFrame

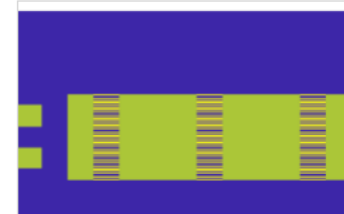
version 1.30



NrPdcchAnalyzer
by Zhu Hengnian

NR PDCCH Analyzer for Single Slot

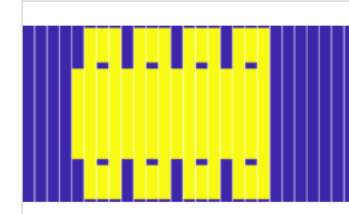
version 1.18



NrPdschAnalyzer
by Zhu Hengnian

NR PDSCH Analyzer for Single Slot

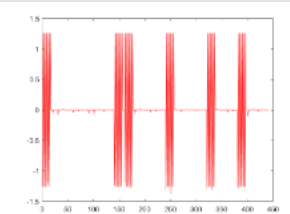
version 1.39



NrSsbAnalyzer
by Zhu Hengnian

NR SSB Analyzer for Single Slot

version 1.28

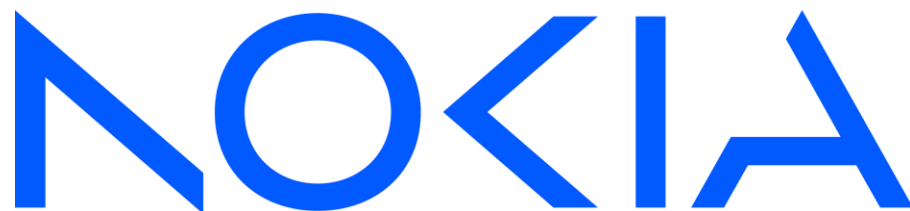


WcdmaDownlinkAnalyzer
by Zhu Hengnian

WCDMA Downlink Common Channel Analyzer

version 1.8

Background



基础网络业务

- IP网络
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过去五年中诺基亚各业务领域（包括诺基亚贝尔实验室）的研发总投入

Background

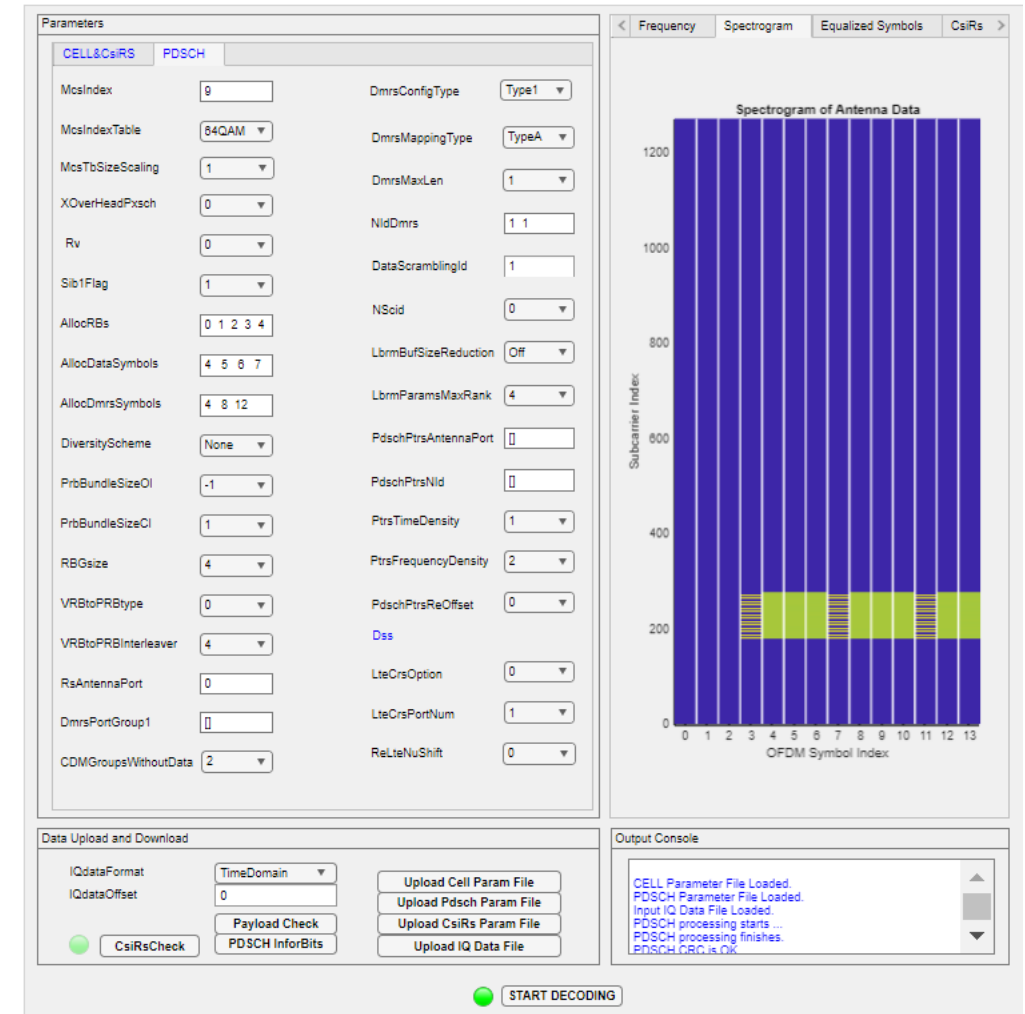


- Our team focuses on physical layer link-level algorithm design and simulation.
- There is a lot of need to analyze baseband data to locate various problems encountered in physical layer software development or test.



Background

- Traditional baseband data analysis is done by link-level algorithm simulators, which requires professional physical layer and MATLAB knowledge, and is difficult for general software engineers or test engineers to get started.
- With the baseband data analysis tool deployed by MATLAB Web App Server, users can directly analyze data online by browsing the web without installing MATLAB and downloading the analysis code.
- The analysis tool provides a standard data and parameter log upload interface, and most of the parameters can be automatically configured through the tool, and graphical analysis results are provided.

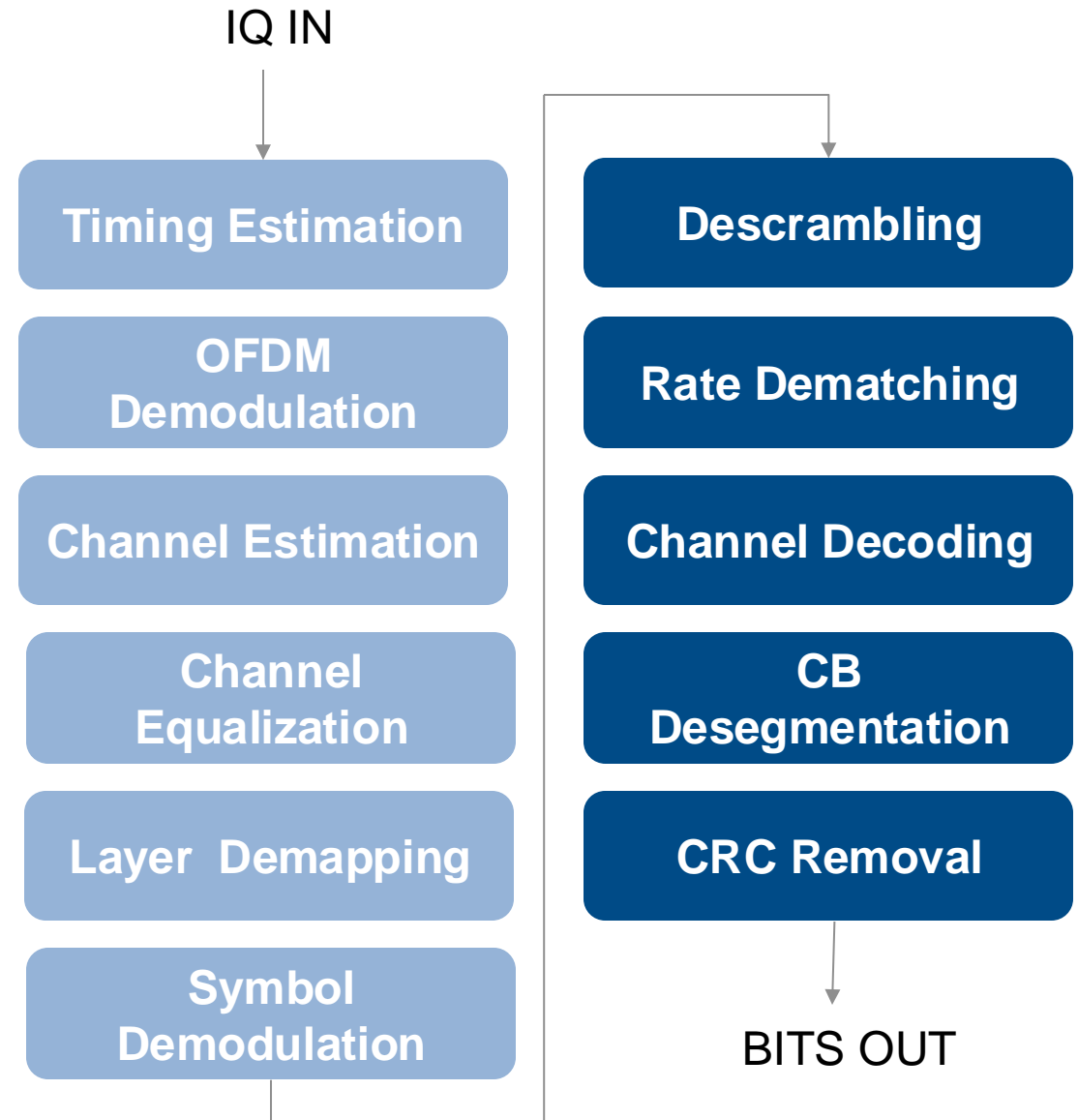


Design downlink receiver using MATLAB

- Support SSB/PDCCH/PDSCH channels, CSI-RS signal.
- Implement symbol-level and bit-level receiver algorithms.

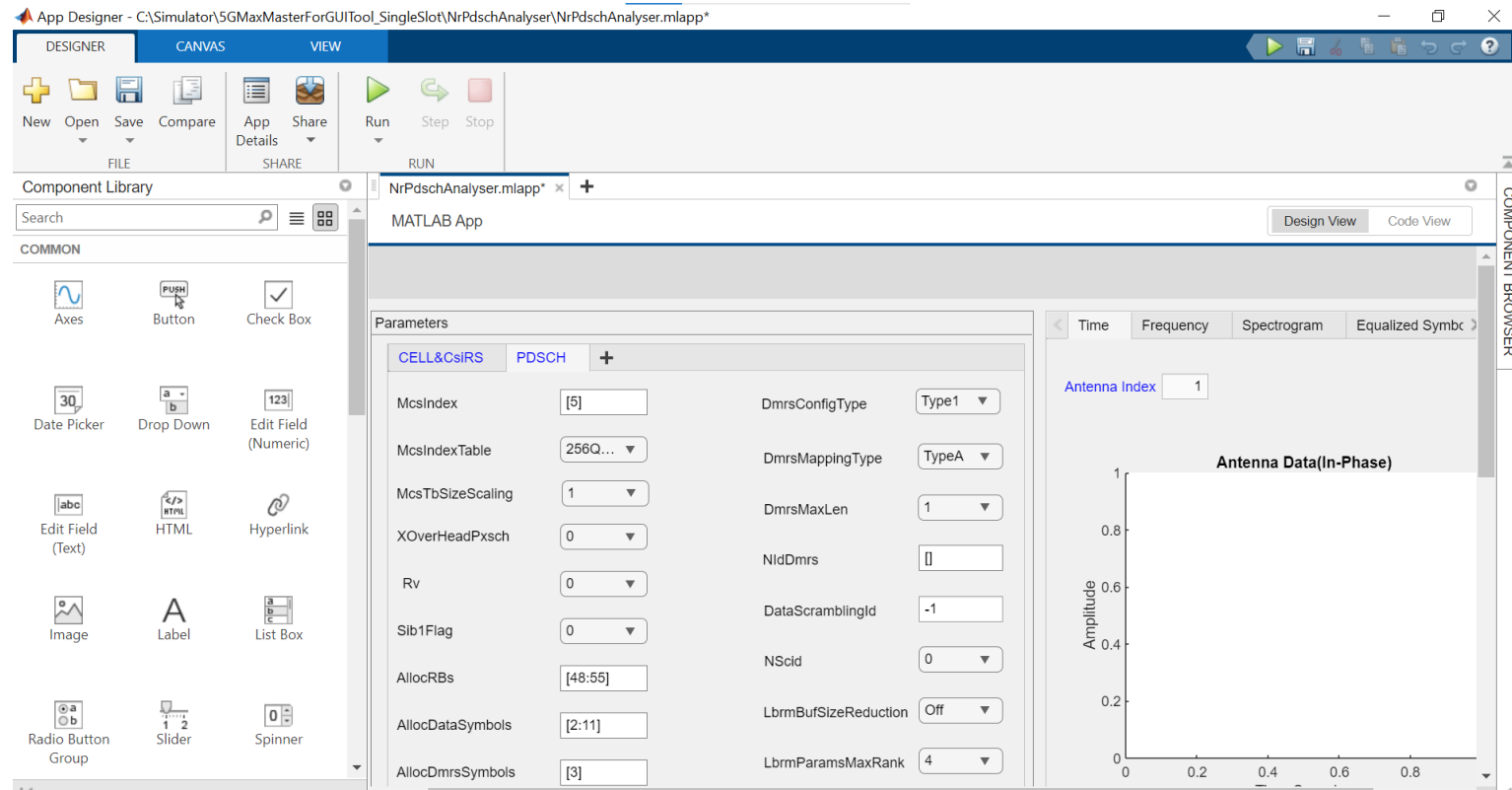
 Symbol Level Processing

 Bit Level Processing



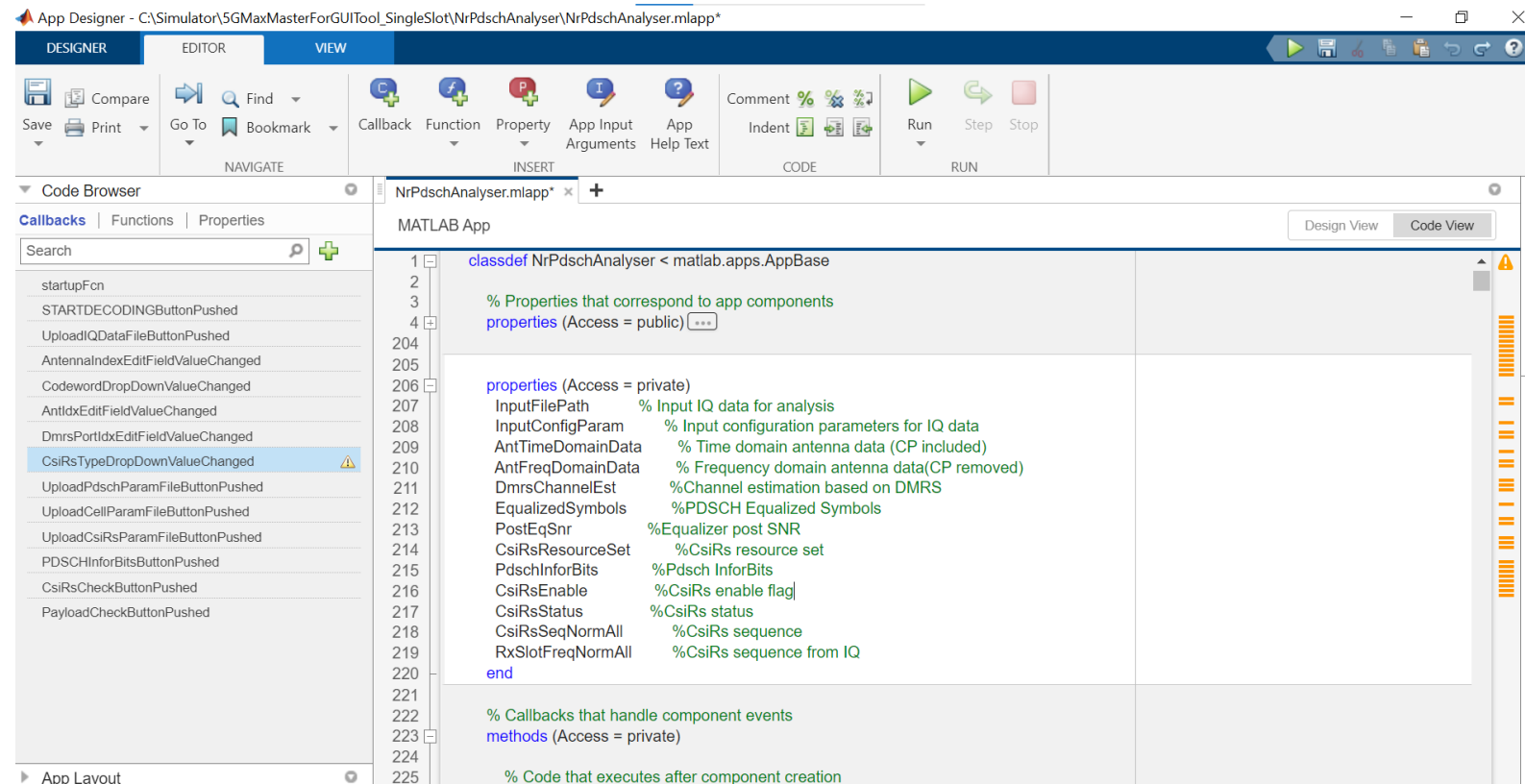
Design baseband data analysis tool using MATLAB App Designer

- Using various GUI components in MATLAB App Designer to design Apps



Design baseband data analysis tool using MATLAB App Designer

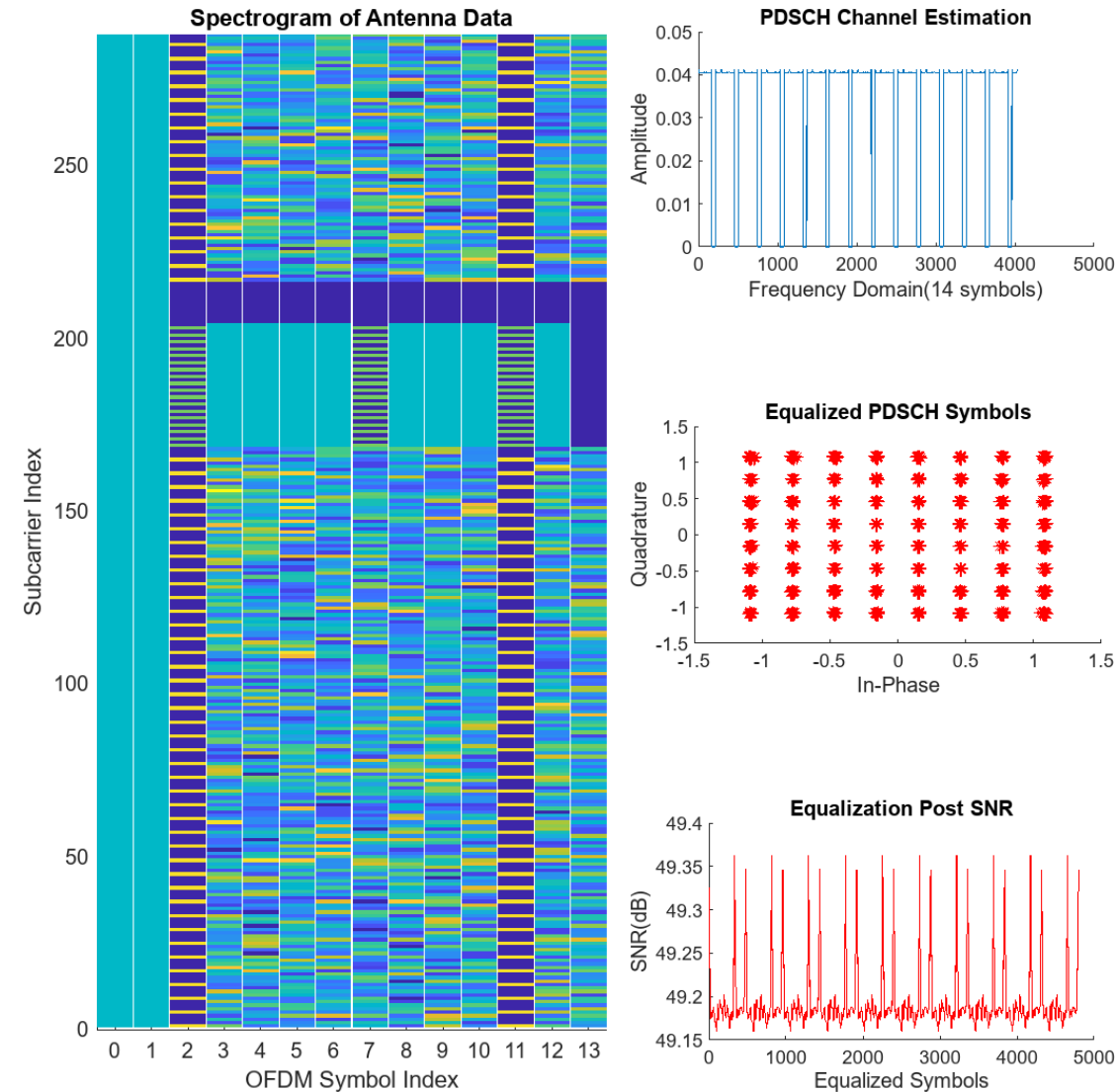
- MATLAB App Designer automatically generates object-oriented MATLAB code based on the design of various GUI components.
- Users can add custom code to the auto-generated MATLAB code.



Design baseband data analysis tool using MATLAB App Designer

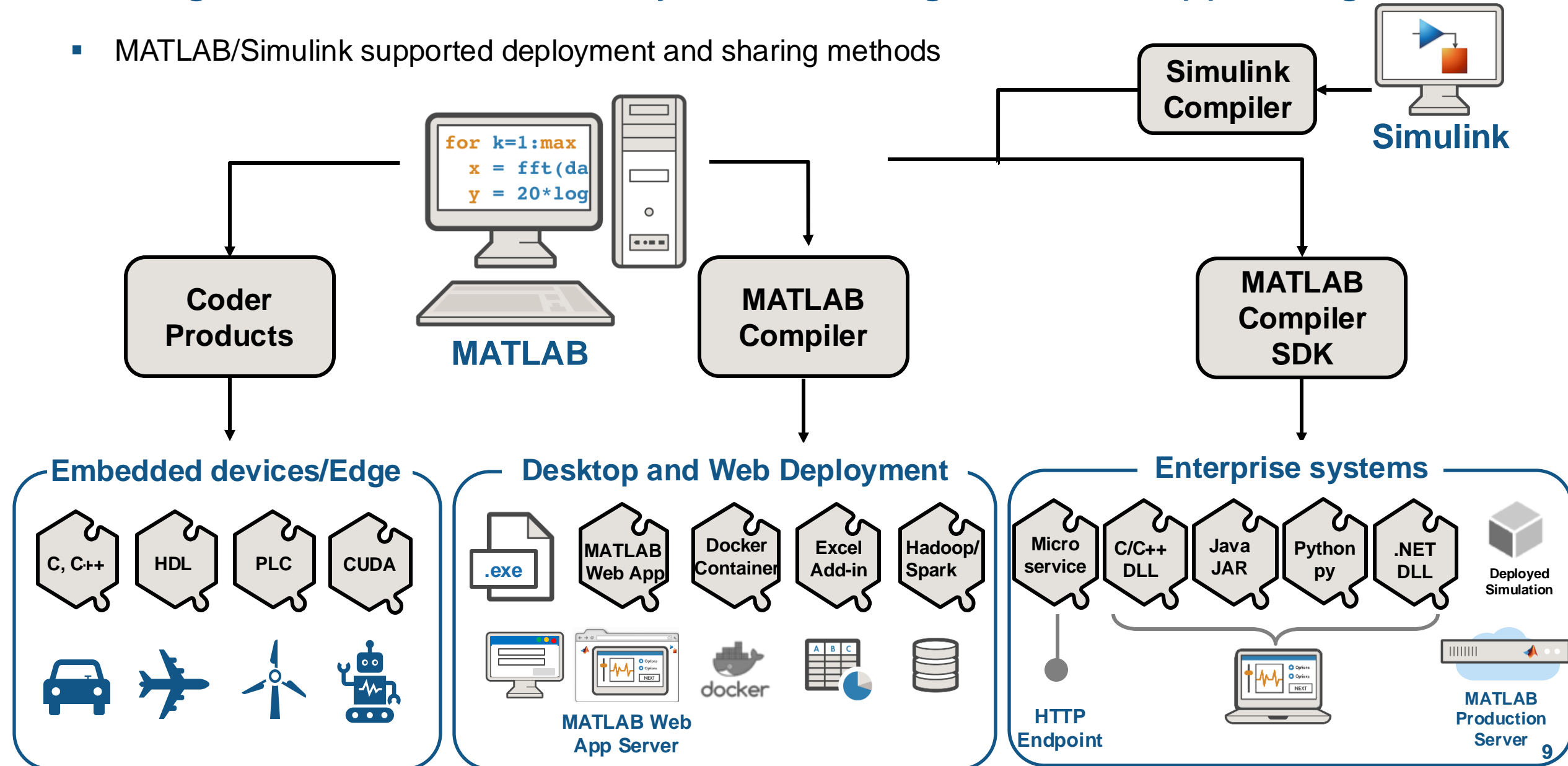
The main functions of the baseband data analysis tool include:

- Read various formats baseband data, including CPRI, ECPRI.
- Read the parameter log and configure the parameters for parsing data based on the parameters in the log.
- The downlink receiver algorithm is used to perform a series of symbol-level and bit-level operations.
- A series of results are displayed graphically, including time-frequency diagram, channel estimation results, and constellation diagram of the symbol after channel equalization. The CRC processing result is displayed in text box.
- Users can download the decoded bit data.



Design baseband data analysis tool using MATLAB App Designer

- MATLAB/Simulink supported deployment and sharing methods



Design baseband data analysis tool using MATLAB App Designer

Programs designed with MATLAB App Designer can be shared in the following ways:

- **MATLAB App**

- Create an App installation file that can be shared among MATLAB users.

- Users can use the App when they install it in MATLAB.

- **Web App**

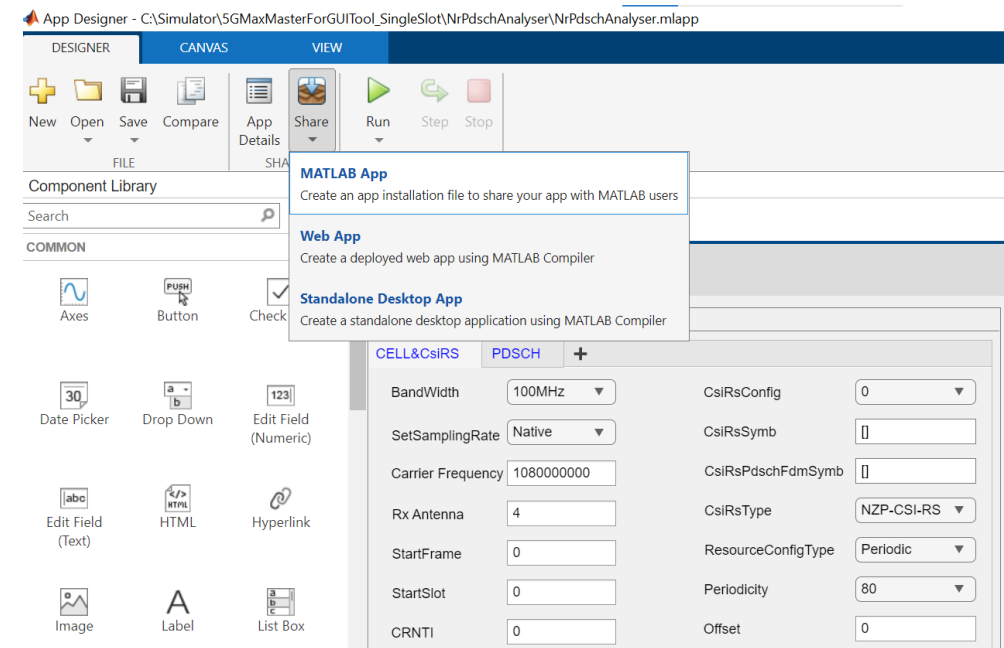
- Create a deployed web App using MATLAB Compiler.

- Deploy the web App using MATLAB App Server. Users can access the App as if they were visiting a web page.

- **Standalone Desktop App**

- Create a standalone desktop App using MATLAB Compiler.

- Users need to install MATLAB Runtime to run desktop App.

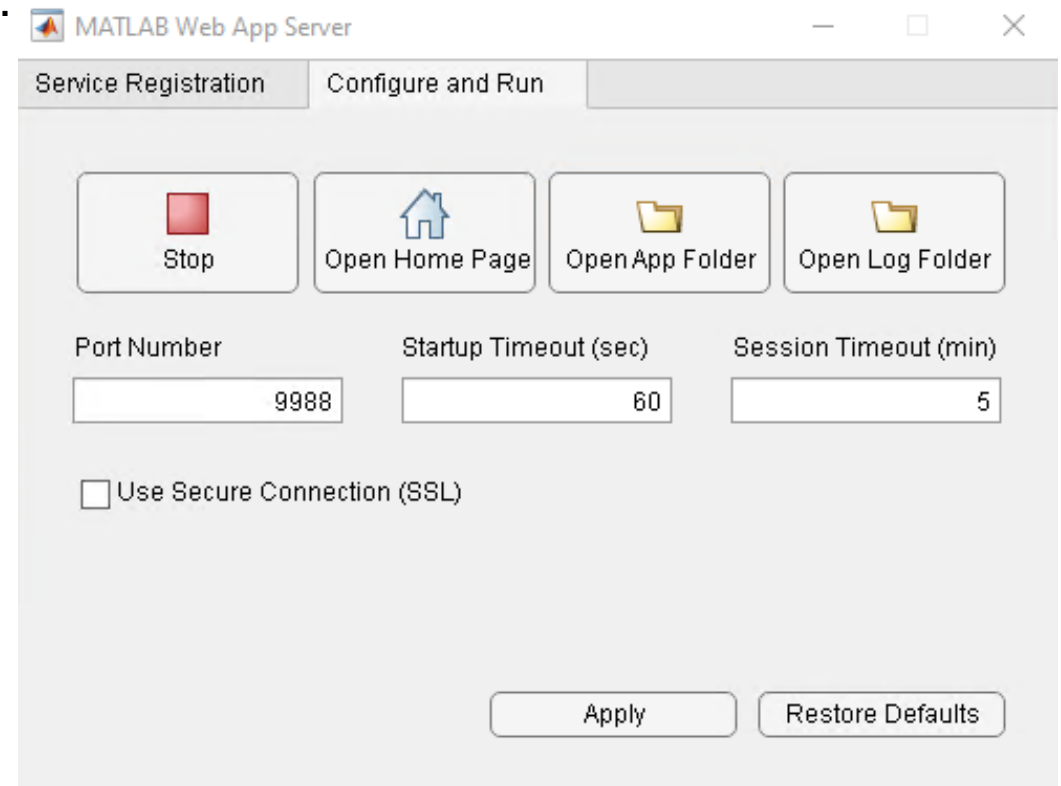


Deploy App using MATLAB Web App Server

We use the way of Web App to share the App we developed.

The benefit of deploying apps by MATLAB Web App Server:























- Enable the centralized management of the app, and the user does not need to update the App.
- Users do not need to install MATLAB or download the App when using the App.
- Users can use the App as if they were visiting the web anytime, anywhere.



Design baseband data analysis tool using MATLAB App Designer

- Applications developed on multiple versions of MATLAB can run on one server
- When an App is updated, you only need to re-compile this App instead of all, which is easy to migrate.

TLAB Web Apps > Manage Apps Upload App Sign Out

Name	Version	Author	MATLAB Runtime	Status Message	
 Mass Spring Damper	1.0	-	R2020a	✓ OK	
 MassSpringDamperAppForLinux	-	-		✗ Expired CTF	
 Mortgage	2.1	MATLAB AppDesigner Examples	R2020a	✓ OK	
 NFLPlayersApp	1.0	MATLAB Connector Team	R2020a	✓ OK	
 PatientsDisplay	1.0	MATLAB AppDesigner Examples	R2020a	✓ OK	
 PatientsTreeAppExample	1.0	MATLAB AppDesigner Examples	R2020a	✓ OK	
 PlotSelector	1.0	MATLAB Graphics Team	R2020a	✓ OK	
 PulseGenerator	1.0	MATLAB AppDesigner Examples	R2020a	✓ OK	
 RoadSuspensionInteractionIn3DOF_SLSimApp	-	-		✗ Expired CTF	
 TMDDSim	2.0	MathWorks SimBiology Team	R2019b	✓ OK	
 TransientConduction	1.0	Dave Garrison	R2020a	✓ OK	

Design baseband data analysis tool using MATLAB App Designer

Develop:

Develop user interfaces and callback functions with MATLAB App Designer

Package:

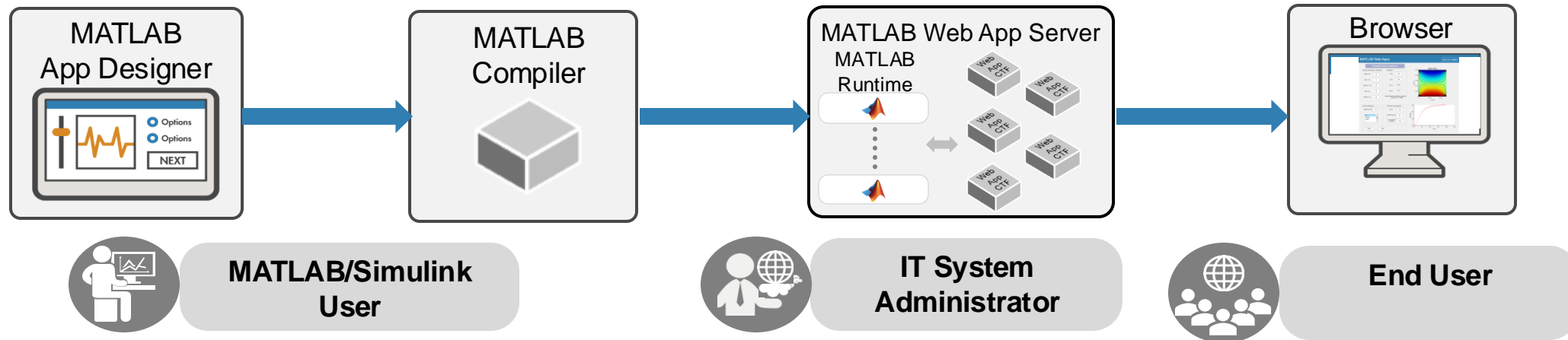
Package MATLAB applications, data, and dependent files with a single click

Deploy:

Use the upload feature to deploy MATLAB Web Apps on a web page

Access and Run:

Direct access MATLAB Web Apps using your browser



Develop shared MATLAB Web Apps

- Share your work with other end users via MATLAB Web Apps
- Spend on App development, not software distribution

Manage basic services

- Security and access control of MATLAB Web Apps
- No software distribution or installation is required, which saves a lot of time

Easy access MATLAB Web Apps

- There is no need to install apps on the desktop, which saves time.
- MATLAB Web Apps can be accessed from anywhere using a browser.

Web App Demonstration

A simple online demonstration of 5G PDSCH baseband data decoding using a Web App.

The screenshot displays the MATLAB Web App Server interface in a web browser. The browser's address bar shows the URL `10.182.100.69:9988/webapps/home/`. The page title is "MATLAB Web App Server". A "Diagnostics" button is visible in the top right corner. The main content area features a grid of 14 web app tiles, each with a thumbnail image, a title, author information, a brief description, and a version number.

App Name	Author	Description	Version
AntMini	by xiaoxiang.li@nokia-sbell.com	Beam Pattern Generation and Plot Tool	version 4.5
BeamPatternPlot	by 5GMAX Downlink Team	Plot Beam Pattern of Beamforming Weight	version 1.0
LteAnalyzerUserGuide	by NSB MN RAN L1 RD HAZ SW 9 SG	LTE Analyzer User Guide	version 1.0
LtePdcchAnalyzer	by Zhu Hengnian	LTE PDCCH Analyzer for Single SubFrame	version 1.11
LtePdschAnalyzer	by Zhu Hengnian	LTE PDSCH Analyzer for Single SubFrame	version 1.30
NrDownlinkIQAnalyzer User Guide	by NSB MN RAN L1 RD SHA SW 2 SG	The User Guide to NR Downlink IQ Analyzer	version 1.0
NrPdcchAnalyzer	by Zhu Hengnian	NR PDCCH IQ Analyzer for multiple slots	version 1.0
NrPdcchAnalyzer	by Zhu Hengnian	NR PDCCH Analyzer for Single Slot	version 1.18
NrPdschAnalyzer	by Zhu Hengnian	NR PDSCH IQ Analyzer for multiple slots	version 1.0
NrPdschAnalyzer	by Zhu Hengnian	NR PDSCH Analyzer for Single Slot	version 1.39
NrSrsAnalyzer	by Zhu Hengnian	NR SRS Multi-Antenna Channel Estimation	version 1.5
NrSsbAnalyzer	by Zhu Hengnian	NR SSB IQ Analyzer for multiple slots	version 1.0
NrSsbAnalyzer	by Zhu Hengnian	NR SSB Analyzer for Single Slot	version 1.28
ReadEcprIQData	by Qian Felpeng	Read Ecpr IQ Data	version 1.35
WedmaDownlinkAnalyzer	by Zhu Hengnian		

Summary

- Using MATLAB's powerful algorithm development capabilities, the core algorithm of 5G downlink receiver is designed.
- Using MATLAB App Designer, an App with a user-friendly GUI is designed to analyze the downlink baseband data.
- Using MATLAB Compiler, the application is compiled as Web App and deployed via MATLAB Web App Server. Users can use the App to analyze downlink baseband data anytime and anywhere as if they were visiting a web page.
- The development time is saved by using MATLAB tools to develop 5G downlink receivers and applications; There is zero-time delay between the tool is published and can be used; The web App becomes a public testing and operation platform within the company, and colleagues around the world can access the App anytime, anywhere, eliminating on-site maintenance and saving communication costs. Colleagues in different teams in China, Poland, United States, Finland, and India are currently using this toolbox for data analysis.
- The toolbox has been in operation for more than two years, and we are constantly improving the toolbox and adding new tools to it as needed, so that this model is more widely promoted.

MATLAB EXPO

Thank you



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