

LTE Uplink Physical Layer Behavioural Model

An end-to-end behavioural model for the LTE Physical layer uplink (UE to eNodeB) in accordance with the 3GPP Release-8 specifications and validated against the RAN4 performance requirements

Abstract

Roke has developed an end-to-end behavioural model for the 3GPP Release-8 LTE Physical layer uplink. The model can be run as a simulation tool to test the performance of the Physical layer algorithms. The eNodeB receive algorithms have been validated against the 3GPP RAN4 performance requirements. The model implements the PUCCH, PUSCH and PRACH channels.

Introduction

Roke Manor Research Ltd (Roke) has developed an end-to-end behavioural model for the LTE Physical layer uplink (UE to eNodeB) in accordance with the 3GPP Release-8 specifications and validated against the RAN4 performance requirements with good implementation margin.

The model uses the (C, floating point) libraries developed by Roke for the UE transmit and eNodeB receive algorithms. The model also incorporates a C++ framework which enables each physical channel to be simulated separately. This simulation capability can be used to test the implementation margin and performance of the Physical layer algorithms under different conditions. This enables the algorithms to be ported to the target platform with confidence.

Behavioural Model

The LTE uplink is based on Single Carrier Frequency Division Multiple Access (SC-FDMA). All the key modules for the LTE Physical layer have been implemented in the Roke uplink behavioural model. The model implements:

- Physical Uplink Control Channel (PUCCH)
- Uplink Shared Channel (PUSCH)
- Random Access Channel (PRACH)

Figure 1 shows the UE transmit chain. Figure 2 shows the eNodeB receive chain.

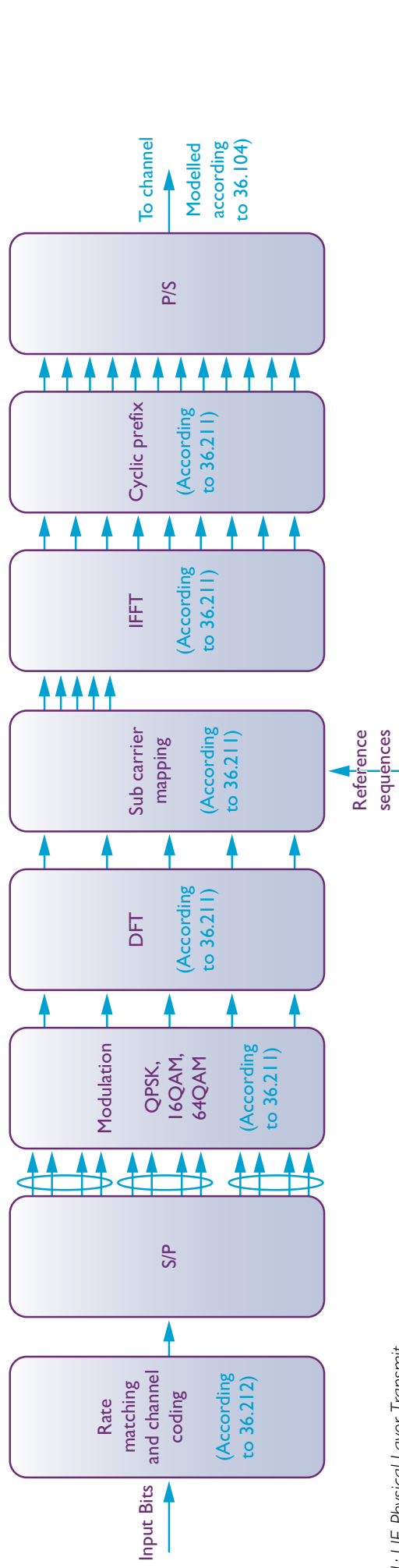


Figure 1: UE Physical Layer Transmit

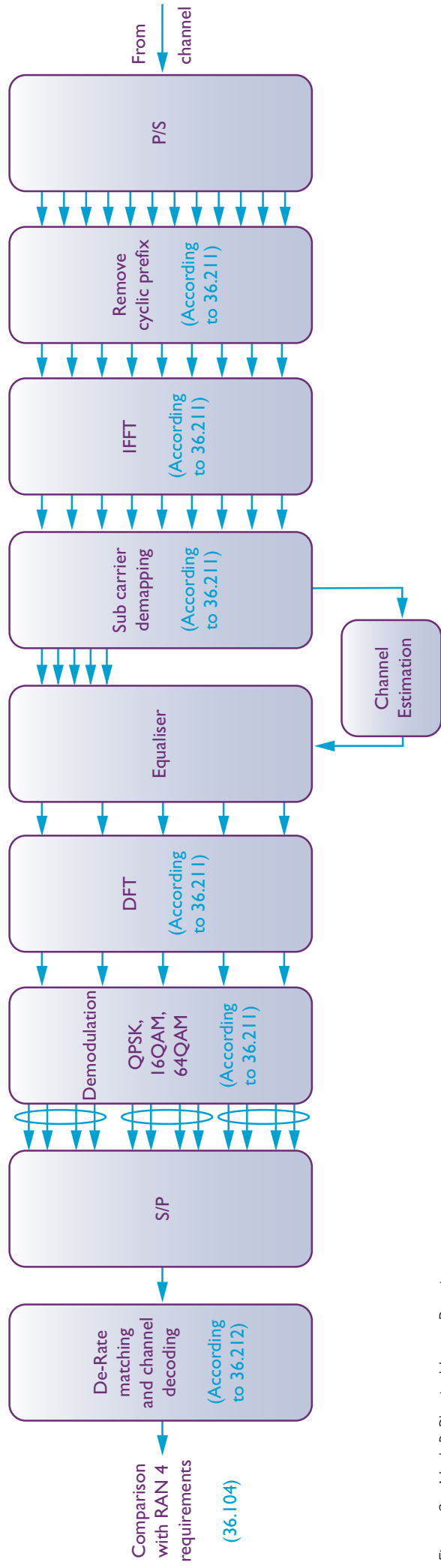


Figure 2: eNodeB Physical Layer Receive

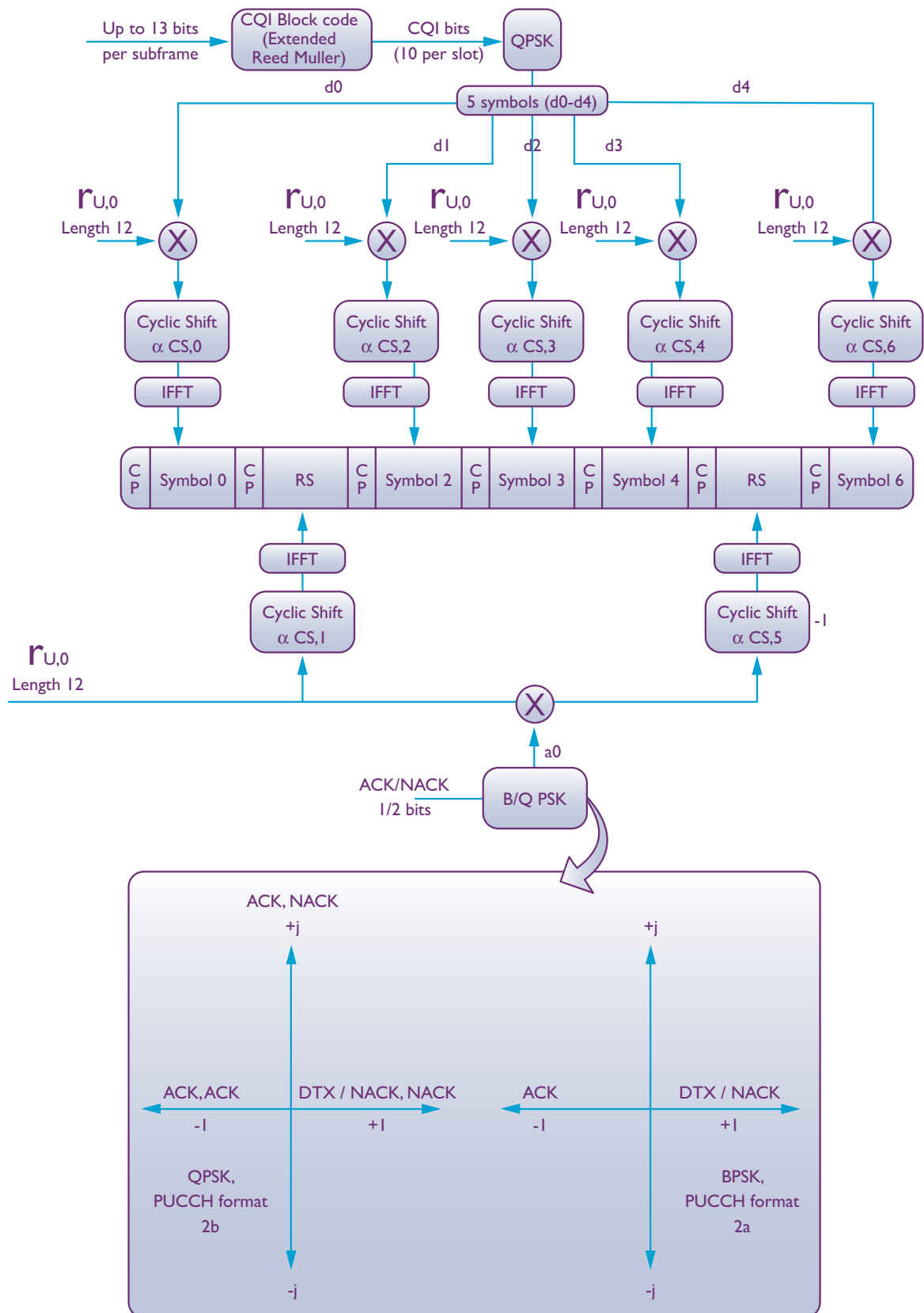


Figure 3: PUCCH Transmit (Format 2, 2a & 2b)

PUCCH (Physical Uplink Control Channel)

The Roke uplink behavioural model implements the PUCCH which is used by the UE to send control information to the eNodeB when the UE does not have a grant for the UL-SCH transport channel. The model implements all the PUCCH formats (1, 1a, 1b, 2, 2a, 2b) as defined in the 3GPP Release-8 specifications.

Figure 3 shows the implementation of the LTE PUCCH transmitter for formats 2, 2a and 2b.

PUSCH (Physical Uplink Shared Channel)

The Roke uplink behavioural model implements the PUSCH which carries UL-SCH transport channel. The eNodeB is responsible for scheduling UE transmission on the PUSCH. All the algorithms used in PUSCH decoding are implemented in C and have been validated against the 3GPP RAN4 performance requirements with good implementation margin.

PRACH (Physical Random Access Channel)

The Roke uplink behavioural model implements the PRACH which is used by the UE for initial access to the cell and scheduling requests. The UE is not guaranteed to be time aligned with the eNodeB when it transmits the random access preamble on the PRACH. The eNodeB may use the random access to calculate and send time alignment commands to the UE. Contention can also occur on the PRACH with multiple UEs transmitting preambles at the same time.

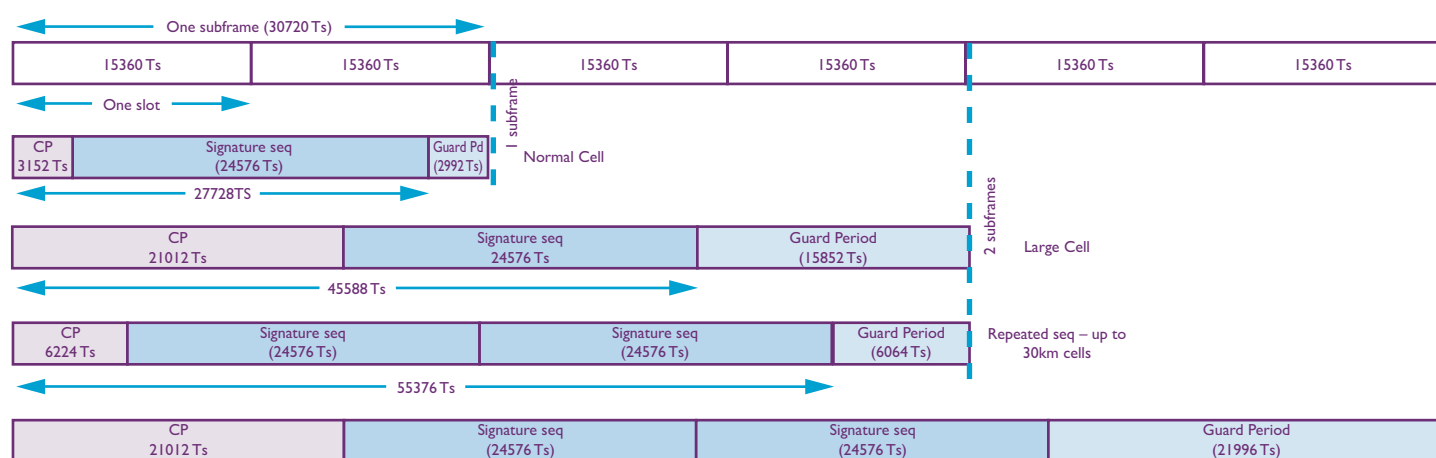


Figure 4 : RA Preamble Formats (0-3)

The model implements all the random access preamble formats (0-3) as defined in the 3GPP Release-8 specifications for frame type 1 (FDD). These are shown in Figure 4. All the algorithms involved in RACH detection have been validated against RAN-4 requirements with good implementation margin.

Summary

Roke has in-depth knowledge of the LTE Physical layer (through involvement in the 3GPP RAN1 working group since 2005) and extensive experience in developing baseband solutions for wireless communications. This knowledge and experience has been used to develop a library of LTE Physical layer transmit and receive algorithms and an end-to-end uplink behavioural model. For further details please contact mobile@roke.co.uk or visit www.roke.co.uk for further details.

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