

Contents

1	Introduction	1
1.1	LTE-A Technologies	1
1.2	LTE-A Relay Standardization	4
1.3	IEEE Relay Standards	5
1.4	Book Objectives and Outline	6
	References	7
2	LTE-A Relay Scenarios and Evaluation Methodology	9
2.1	Relay Scenarios	9
2.1.1	Rural Area	9
2.1.2	Urban Hot Spot	10
2.1.3	Dead Spot	11
2.1.4	Indoor Hot Spot	12
2.1.5	Group Mobility	14
2.1.6	Emergency or Temporary Network Deployment	17
2.1.7	Wireless Backhaul Only	17
2.2	Channel Modeling	19
2.2.1	Large Scale Fading Modeling for RN–UE Connection	20
2.2.2	LOS Probability of RN–UE Connection	22
2.2.3	Large Scale Fading Modeling for eNB–RN Connection	24
2.2.4	LOS Probability eNB–RN Connection	26
2.3	Impacts of Relay Site Planning	28
2.3.1	Less Attenuation from Donor eNB	28
2.3.2	Improvement of LOS Probability in Donor eNB–RN Connection	31
2.4	Large Scale Fading Parameters	33
2.5	Small Scale Fading	33
2.6	Other Settings	38
	References	38

3	LTE-A Relay Study and Related Technologies	39
3.1	Relay Categorization Based on Protocol Architecture	39
3.1.1	L1 Relay	40
3.1.2	L2 Relay	40
3.1.3	L3 Relay	41
3.2	Operating Band	43
3.2.1	Brief Description of LTE-A Carrier Aggregation	44
3.2.2	Relay with Carrier Aggregation	46
3.3	Number of Hops	52
3.4	Type 1 Relay	53
3.4.1	Definition	54
3.4.2	Technology Aspects	55
3.4.3	Semi-Analytical Evaluations	57
3.4.4	Downlink Performance Evaluation with Uniformly Distributed Relay Nodes	59
3.4.5	Downlink Performance Evaluation with Relay Nodes Placed Near Cell Edges	63
3.4.6	Uplink Performance Evaluation with Relay Nodes Placed Near Cell Edges	67
3.5	Type 2 Relay	72
3.5.1	Definition	72
3.5.2	Technologies	72
3.5.3	Performance Evaluations	82
3.6	Other Related Technologies in LTE-Advanced	86
3.6.1	Downlink Reference Signals	86
3.6.2	Enhanced ICIC	88
3.6.3	CoMP	90
	References	90
4	Physical Layer Standardization of Release 10 Relay	91
4.1	Scenario	91
4.2	Physical Layer Control Channel Specification	92
4.2.1	Relay Downlink Frame Timing	94
4.2.2	Configuration of Start Symbol of R-PDCCH and PDSCH	96
4.2.3	Relay Uplink Frame Timing	97
4.2.4	Relay Node Synchronization	100
4.2.5	R-PDCCH Multiplexing	103
4.2.6	Reference Signal	108
4.2.7	Cross-Interleaved and Non Cross-Interleave R-PDCCH	112
4.2.8	PUCCH	119

- 4.3 Backhaul Subframe Configuration and HARQ Timing 120
 - 4.3.1 FDD systems 121
 - 4.3.2 TDD Systems 126
 - References 133
- 5 Higher Layer Aspects and RAN4 Performance Aspects 135**
 - 5.1 Relay Architecture 135
 - 5.2 C-Plane Procedures 138
 - 5.3 U-Plane Procedures 141
 - 5.4 S1/X2 Procedures 142
 - 5.5 Release 10 Relay Performance Aspects 143
 - 5.5.1 RF Requirements in General 144
 - 5.5.2 RF Requirements for Backhaul Link 145
 - 5.5.3 RF Requirements for Access Link 146
 - 5.5.4 Baseband Requirements 146
 - 5.5.5 Synchronization Requirements 148
 - References 148
- 6 Implementation Aspects of Release 10 Relay 149**
 - 6.1 General Consideration of PHY Layer Implementation 149
 - 6.2 Baseband Realization of Relay Node 150
 - 6.2.1 Channel Characteristics of Backhaul and Access Links 152
 - 6.2.2 Common Reference Signal Demodulation 153
 - 6.2.3 DL DMRS Demodulation 154
 - 6.2.4 Search Space for R-PDCCH Without Cross-Interleaving 155
 - 6.2.5 Choice for Relay Timing 156
 - 6.3 Radio Modules and Antennas of Relay Node 157
 - 6.3.1 Power Amplifier and Filters 157
 - 6.3.2 Clock Synchronization 158
 - 6.3.3 Antennas 159
 - 6.4 Relay Node Scheduler 159
 - 6.4.1 Deployment Scenarios 160
 - 6.4.2 Relay Frame Timing 160
 - 6.4.3 Access Link HARQ 161
 - 6.4.4 Uplink Power Control for UEs in RN Cell 162
 - 6.4.5 Data Buffering 162
 - 6.5 Baseband Implementations in Donor eNB 163
 - 6.6 Scheduler at Donor eNB 164
 - 6.6.1 Resource Allocations for R-PDCCH 164
 - 6.6.2 Transport Block Size Determination and MCS Selection 166
 - 6.6.3 Configurations of CSI Feedback and SRS 168

6.6.4	Resource Scheduling for PDSCH	169
6.6.5	Open Loop Uplink Power Control for RNs	171
6.7	Relay Network Planning.	171
6.7.1	Number of RNs	171
6.7.2	RN-to-RN Interference	172
6.7.3	Cell Range Expansion and ABS Configuration.	173
	References	175
7	Outlook of Relay in Future LTE Releases.	177
7.1	Some Trends in Mobile Communications.	177
7.1.1	Trends at Terminal Side	177
7.2	Cooperative Relays	180
7.3	Relay Backhaul for High Speed Mobility.	183
7.4	Cooperative Mobile Relay	184
7.5	Local Server.	184
	References	185