IMPROVE ENERGY EFFICIENCY IN COOPERATIVE MEDIUM ACCESS CONTROL PROTOCOL FOR WIRELESS NETWORKS

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LIST OF ABBREVIATIONS

ACK	Acknowledgement
ADC MAC	Adaptive distributed cooperative medium access control protocol
AF	Amplify-and-forward
AI	Artificial intelligence
AWCN	Additive white Gaussian noise
CLMAC	Cross-layer cooperative medium access control protocol
CMAC	Cooperative medium access control protocol
CoopMAC	Cooperative medium access control protocol
CoRe-MAC	Cooperative relaying medium access control protocol
COMAC	Cross-layer cooperative medium access control protocol
CRBAR	Cooperative relay-based rate adaptation protocol
CTS	Clear-to-send packet
CSMA/CA	Carrier sense multiple access/collision avoidance
DCMAC	Distributed cooperative medium access control protocol
DEL-CMAC	Distributed energy-adaptive location-based cooperative medium access control protocol
DF	Decode-and-forward
DIFS	Distributed coordination function inter-frame spacing
DO	Dual objective
DTMC	Discrete-time Markov chain
EAP-CMAC	Energy-aware cross-layer cooperative medium access control protocol
EECO-MAC	Energy-efficient cooperative medium access control protocol
EE-CR	Energy-efficient cooperative relaying protocol

EH	Energy harvesting
EH-CMAC	Energy harvesting cooperative medium access control protocol
EI	Energy information
ETH	Eager-to-help packet
E2E	End-to-end
GC-RS	Group contention-based relay selection
HRF	Helper-ready-to-forward packet
HRTC	Helper-ready-to-cooperate
IEEE	Institute of electrical and electronics engineers
II	Interference indicator
IP	Information processing
KKT	Karush Kuhn-Tucker
LAN	Local area network
LC-MAC	Link utility-based cooperative medium access control protocol
LEA-CMAC	Lifetime extension–aware cooperative medium access control protocol
LETPO	Lifetime extension transmission power optimization
LI	Location information
LQI	Link quality information
MAC	Medium access control layer
MANET	Mobile ad-hoc network
MAPE	Monitor, analyze, plan and execute
MATLAB	MATrix LABoratory
MO	Multiple objective
MIMO	Multiple-input-multiple-output
MRC	Maximum ratio combining

NACK	Negative acknowledgement
NAV	Network allocation vector
NCAC-MAC	Network coding-aware cooperative medium access control protocol
NCCARQ-MAC	Network coding cooperative automatic repeat request medium access control protocol
NCS-CR	Network coding supported-cooperative retransmission
NET	Network layer
P-CR	Pure-cooperative retransmission
PHY	Physical layer
PI	Power information
PNC	Physical network coding
PO-CMAC	Power optimized cooperative medium access control protocol
PO-MAC	Optimized-power cooperative medium access control protocol
PO-PS-CMAC	Power optimized power-splitting energy harvesting cooperative medium access control optimized
PO-TS-CMAC	Power optimized time switching-energy harvesting cooperative medium access control optimized
PS	Power splitting
PS-EH-CMAC	Power-splitting-energy harvesting cooperative medium access control
QoS	Quality-of-service
QSI	Quality of service information
RBAR	Receiver-based rate adaptive protocol
rDCF	Relay-enabled distribution coordination function protocol
REI	Residual energy information
RF	Radio frequency
RRS-MAC	Rapid relay selection cooperative medium access control

RTS	Ready-to-send packet
SA-RS	Splitting algorithm-based relay selection
SIFS	Short inter-frame spacing
SII	Signal interference information
SINR	Signal-interference-noise ratio
SNR	Signal-to-noise ratio
SO	Single objective
TDMA	Time division multiple access
TS	Time switching
TS-EH-CMAC	Time-switching energy harvesting cooperative medium access control protocol
TWT	Two-way relaying
VCS	Virtual carrier sensing
WANET	Wireless ad-hoc network
WLAN	Wireless local area networks
WSN	Wireless sensor network
2rcMAC	Two-relay cooperative medium access control

LIST OF SYMBOLS

α	Time switching ratio
$A_{l_x,l_y}(d)$	The overlap area or cooperative region
$b_{i,j,k}$	The steady-state probability of the 3-D Markov model
$b(t)$	The stochastic process of the residual suspension time k.
β	Unit time
BU_r	The backoff function at the ith relay
C_{S,r_i}	The channel capacity at the ith relaying
$C_{r_i,D}$	The channel capacity at the destination
CW_{min}	The minimum contention window size
δ	Propagation delay
d	The distance between two terminals
d_{S,r_i}	The distance between S and r_i
$d_{r_i,D}$	The distance between r_i and D
D	Destination terminal
D_{RTS}	RTS duration time
D_{CTS}	CTS duration time
D_{HRF}	HRF duration time
D_{HRTC}	HRTC duration time
D_{DATA}	DATA duration time
ε	Step size
ξ	The conditional collision probability
e	The minimum residual energy in the network after cooperation
E_o	The initial energy of all nodes

E_s	The residual energy at the source
E_{r_i}	The residual energy at the ith relay
$E_{r_i}^C$	The estimated energy to be consumed by ith potential relay nodes when cooperating
E_s^D	The estimated energy consumed for direct transmission
$E_{r_i}^C$	The estimated energy to be consumed by the relay node cooperating
E_{min}	The minimum residual energy in the network
$\mathrm{E}\{\cdot\}$	The expectation operator
f_x	The fractions of the S to D pairs with direct transmission rates of x Mbps
Flag_1	To determine if cooperation is required
Flag_2	To select the type of cooperation
h_{S,r_i}	The independently distributed Rayleigh fading channel gain between S and r_i
$h_{r_i,D}$	The independently distributed Rayleigh fading channel gain between r_i and D
$\mathcal{L}\{\cdot\}$	Lagrange function
l_x	Transmission range of x Mbps
L	Packet length
L_H	PHY-MAC header
$\lambda, \mu, z, u, \sigma, \rho$	Lagrange multipliers
m	Maximum retry limit
η	Energy efficiency conversion coefficient
n	Number of iterations
$n_{r_i}(t)$	Additive white Gaussian noise at the ith helper terminal.
$n_{r_i}(t)$	Additive white Gaussian noise at the destination terminal.
N	Number of relays

N_o	Noise power of AWGN channel
ϑ	Power splitting ratio
p_c	The probability of collision in the transmitting nodes
p_e	The probability of transmission error in the transmitting nodes
P	The power factor in PS relaying
P_S	The maximum transmit power at the source terminal for EH
P_t^D	Transmit power for the direct link
P_t^S	Transmit power at the source node
$P_{t\,max}$	Fixed transmit power
P_{tr}	The probability that the channel medium is busy
P_s	The probability of successful transmission for each mode
P_e	The probability of unsuccessful transmission due to error in the other node
P_c	The probability of collision transmission in the other node
$P_t^{r_i}$	Transmit power at the ith relay node
$P_{r_i}^{TS}$	Retransmission power at the relaying node for TS relaying
$P_{r_i}^{PS}$	Retransmission power at the ith relaying node for PS relaying
P_{TX}	Processing power at the transmitter
P_{RX}	Receiving power
P_S^{*C}	The optimal transmit power at the source
$P_{r_i}^{*C}$	The optimal transmit power at the ith relaying node
P_{out}	The outage probability of the direct link
P_{out}^{X-EH}	The outage probability for a DF reactive relaying at the destination
$p_{5.5.,5.5}(d)$	The probability that a helper terminal located in the coverage area
$P_{5.5,5.5}$	The probability that there exists at least one helper terminal that would support a dual-op transmission with (x, y) Mbps rate

P_s^{DT}	The probability of successful Legacy 802.11 MAC
$P_s^{CoopMAC}$	The probability of successful CoopMAC
$P_s^{PO-CMAC}$	The probability of successful PO-CMAC
$P_s^{TS-EH-CMAC}$	The probability of successful TS-EH-CMAC
$P_s^{PS-EH-CMAC}$	The probability of successful PS-EH-CMAC
$P_s^{PO-TS-CMAC}$	The probability of successful PO-TS-CMAC
$P_s^{PO-PS-CMAC}$	The probability of successful PO-PS-CMAC
r_i	The ith relay terminal
R_{th}	Threshold transmission rate
R	Transmission rate
$R_{S,D}$	Data-rate between source and destination
R_{coop}	Data-rate of the cooperative transmission mode
$R_{X-EH-Coop}$	Data-rate of the EH-enabled cooperative transmission mode
$s(t)$	The stochastic process of the backoff time
S	Source terminal
τ	The stationary packet transmission probability
$\mathbb{T}$	Saturated throughput
T	Block time
T_{RTS}	The transmission time of the control frames RTS frame
T_{CTS}	The transmission time of the control frames CTS frame
T_{HRF}	The transmission time of the control frames HRF frame
T_{DATA}	The transmission time of the data packet
T_{ACK}	The transmission time of the control frames ACK frame
$T_{\max BO}$	The maximum backoff for the relay nodes
$T_{ACK\ timeout}$	ACK timeout

T_e	Duration of unsuccessful transmission due to error
T_s	The average transmission time
T_x	The average packet transmission time for S to D pairs with a data-rate of x Mbps
$T_{LEA-CMAC\ OH}$	LEA-CMAC overhead
T_{OH}	Legacy 802.11 MAC overhead
T_c	The collision time
$\bar{T}_s$	The average of the T_s observed by other nodes in the network
$\bar{T}_e$	The average of the T_e observed by other nodes in the network
$\bar{T}_c$	The average of the T_c observed by other nodes in the network
T_s^{DT}	The duration of successful Legacy 802.11 MAC
$T_s^{CoopMAC}$	The duration of successful CoopMAC
$T_s^{PO-CMAC}$	The duration of successful PO-CMAC,
$T_s^{TS-EH-CMAC}$	The duration of successful TS-EH-CMAC
$T_s^{PO-TS-CMAC}$	The duration of successful PO-TS-CMAC
$T_s^{PS-EH-CMAC}$	The duration of successful PS-EH-CMAC
$T_s^{PO-PS-CMAC}$	The duration of successful PO-PS-CMAC
$\psi_{r_i}^{TS}$	The harvested energy at the ith relay node for TS
$\psi_{r_i}^{PS}$	The harvested energy at the ith relay node for PS
$u(t)$	The stochastic process of the residual suspension time k
v	Path-loss exponent
$x(t)$	The normalized information symbol from S, with $\mathrm{E}\{\lfloor x(t) \rfloor^2\} = 1$,
$\hat{x}(t)$	The re-encoded signal
X	The subset of TS and PS
$y_{r_i}(t)$	The received signal at the ith helper terminal

$y_D(t)$	The received signal at the destination terminal
γ_{S,r_i}^{TS}	The instantaneous received SNR at the ith relay nodes for TS relaying
$\gamma_{r_i,D}^{TS}$	The instantaneous received SNR at the destination nodes for TS relaying
γ_{S,r_i}^{PS}	The instantaneous received SNR at the ith relay nodes for PS relaying
$\gamma_{r_i,D}^{PS}$	The instantaneous received SNR at the destination nodes for PS relaying
γ_{th}	Threshold SNR