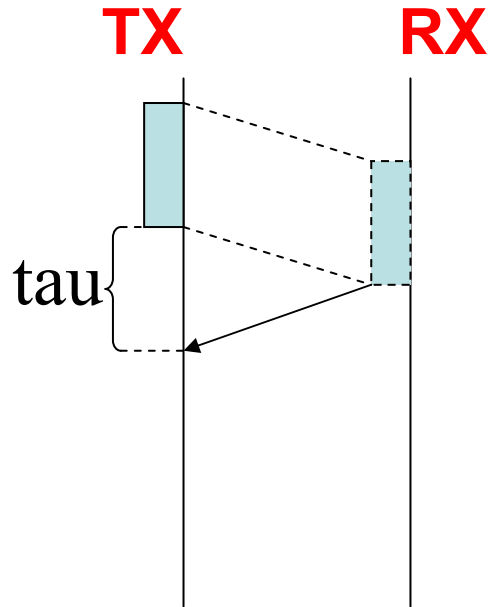


Queueing analysis of GbN ARQ for wireless channel

Konstantin Dubkov, SUAI

Simple Model



Assumptions

- Format:

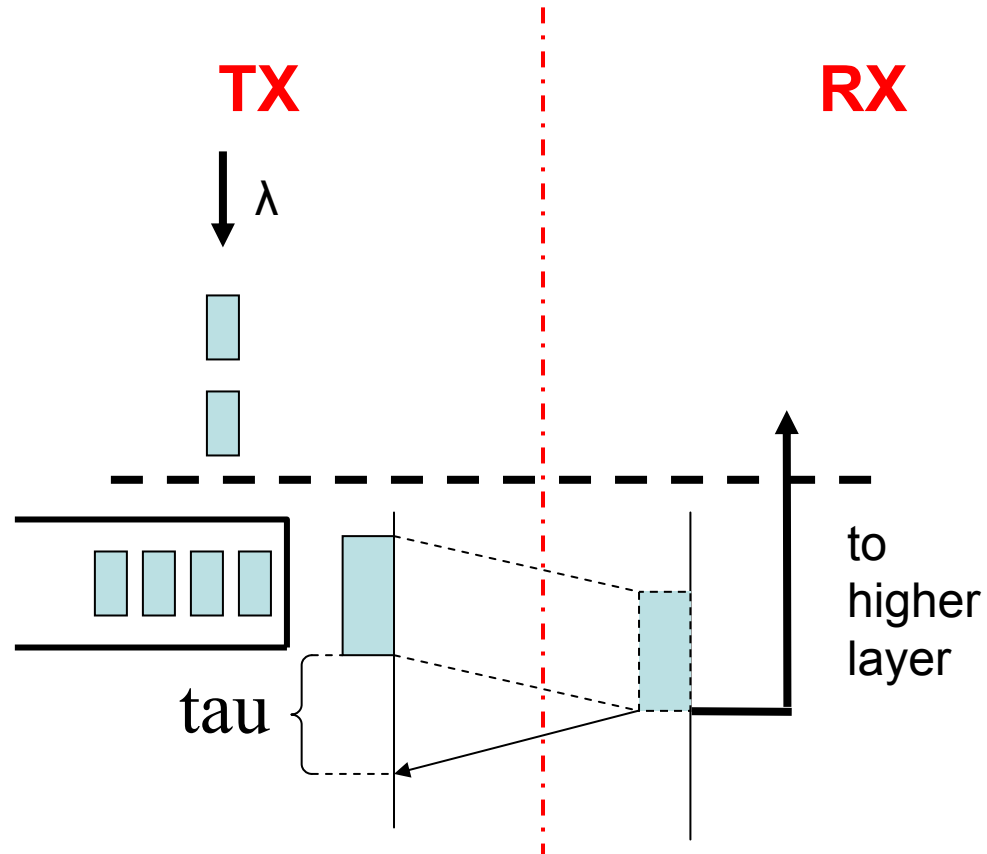
Data	CRC
------	-----
- Error probability – PER
- FB channel – Ack/Nack
- Error free FB channel
- $\tau=0$

Algorithm:

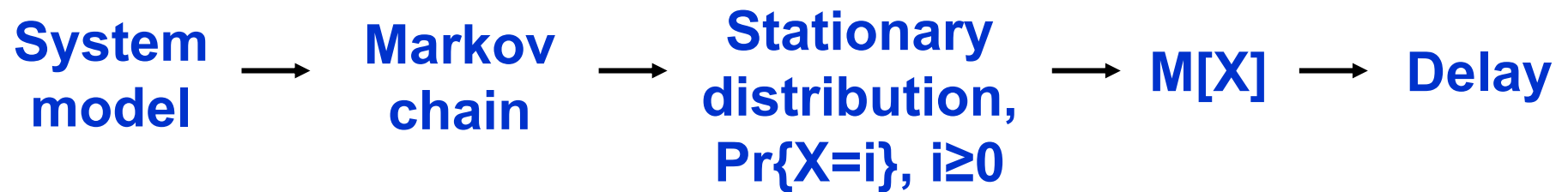
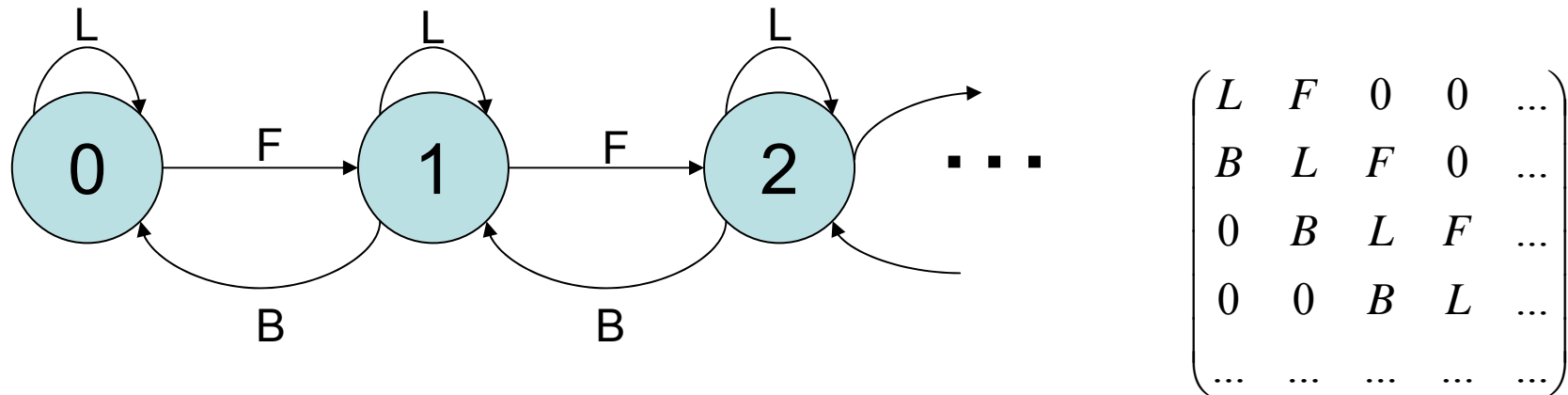
1. Transmit packet
 2. Wait for and receive Ack/Nack
 3. If (Ack) turn to next packet
 4. Go to step 1
- Send packet to higher level

} TX
RX

Higher layer assumptions



Analysis - Markov Chain



X – number of packets in the system

Analysis - alternative method

- In stable state $M[X(t)] = M[X(t+1)] = M[X]$
- Obtain $M[X] = f(\lambda, PER)$
- Short derivation:

$$X_{n+1} = X_n - I'_n + A_n \quad I'_n = \begin{cases} 0, & \Pr\{X_n > 0\}PER + (1 - \Pr\{X_n > 0\}) \\ 1, & \Pr\{X_n > 0\}(1 - PER) \end{cases}$$

$$M[X] = M[X] - M[I'_n] + M[A]$$

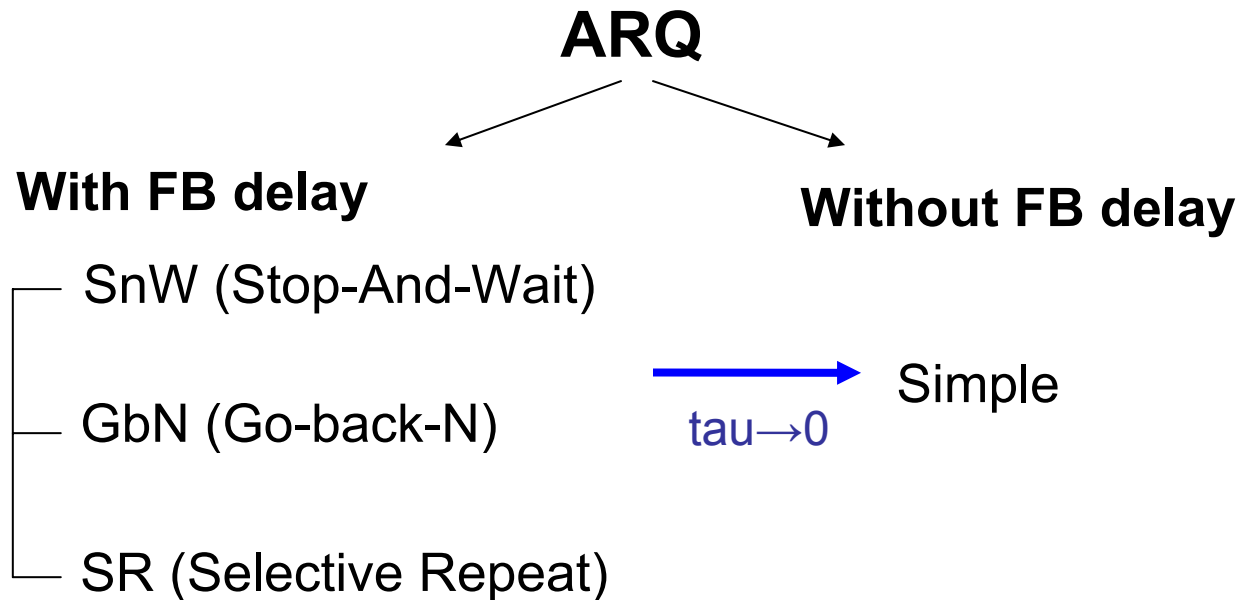
$$\Pr\{X_n > 0\} = \frac{\lambda}{1 - PER}$$

$$M[X^2] = M[X^2] + M[(I'_n)^2] + M[A^2] - 2M[X_n I'_n] - 2M[I'_n A_n] + 2M[X_n A_n]$$

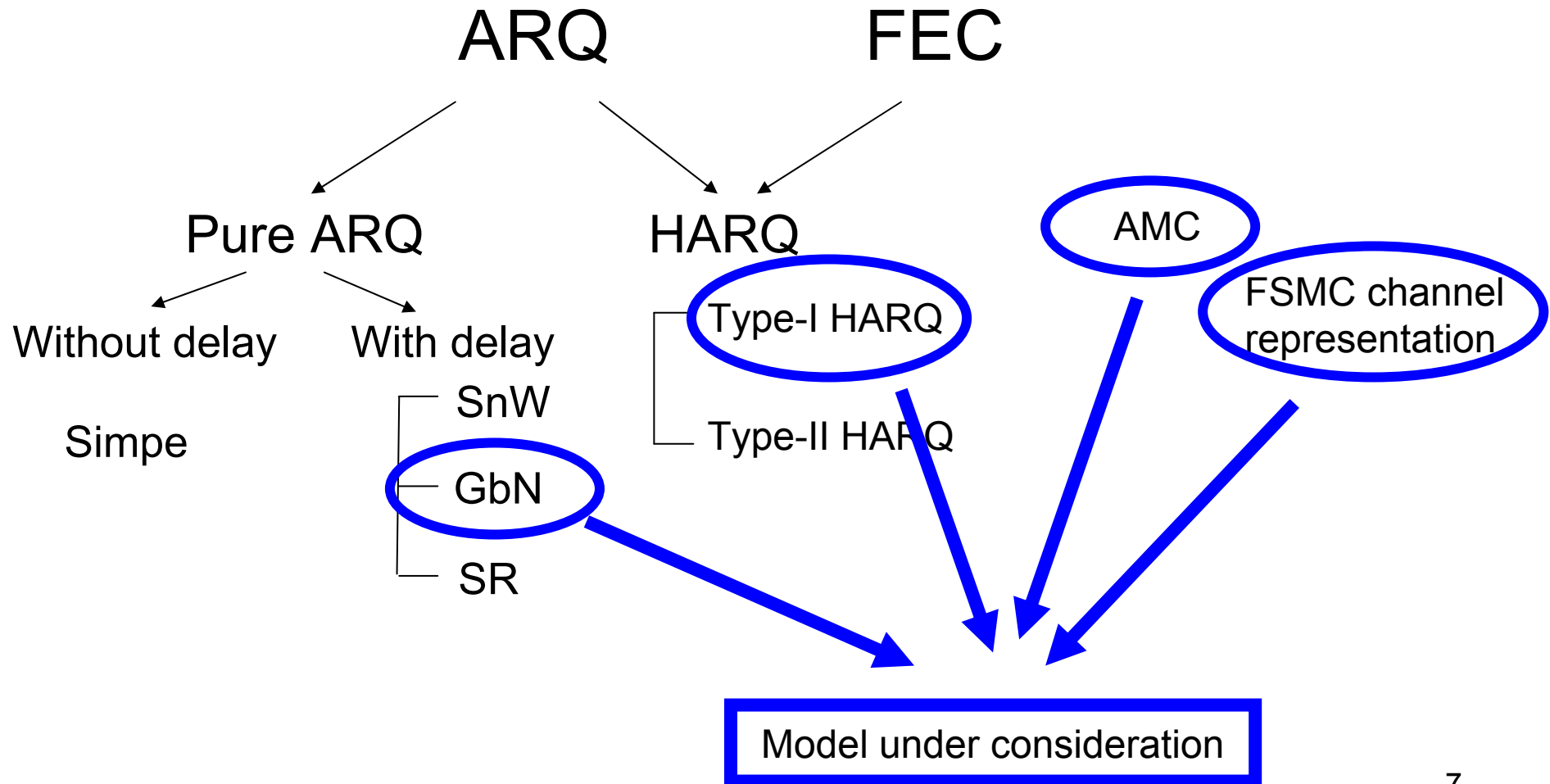
$$M[X] = \frac{2\lambda - \lambda^2}{2(1 - \lambda - PER)}$$

ARQ algorithms classification

ARQ - Automatic Repeat Request



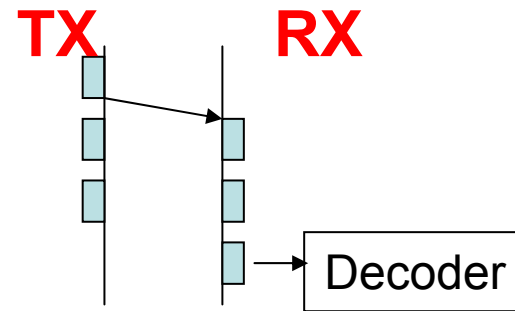
Model under consideration



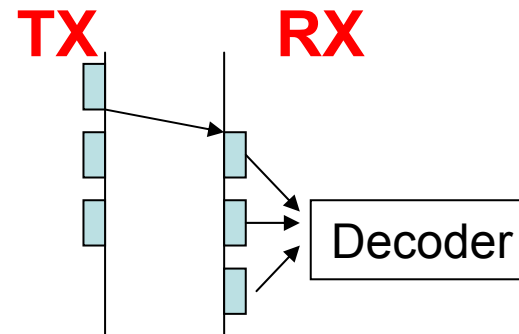
HARQ

- HARQ = ARQ + FEC
 - FEC - Forward Error Correction

- Type-I Hybrid ARQ



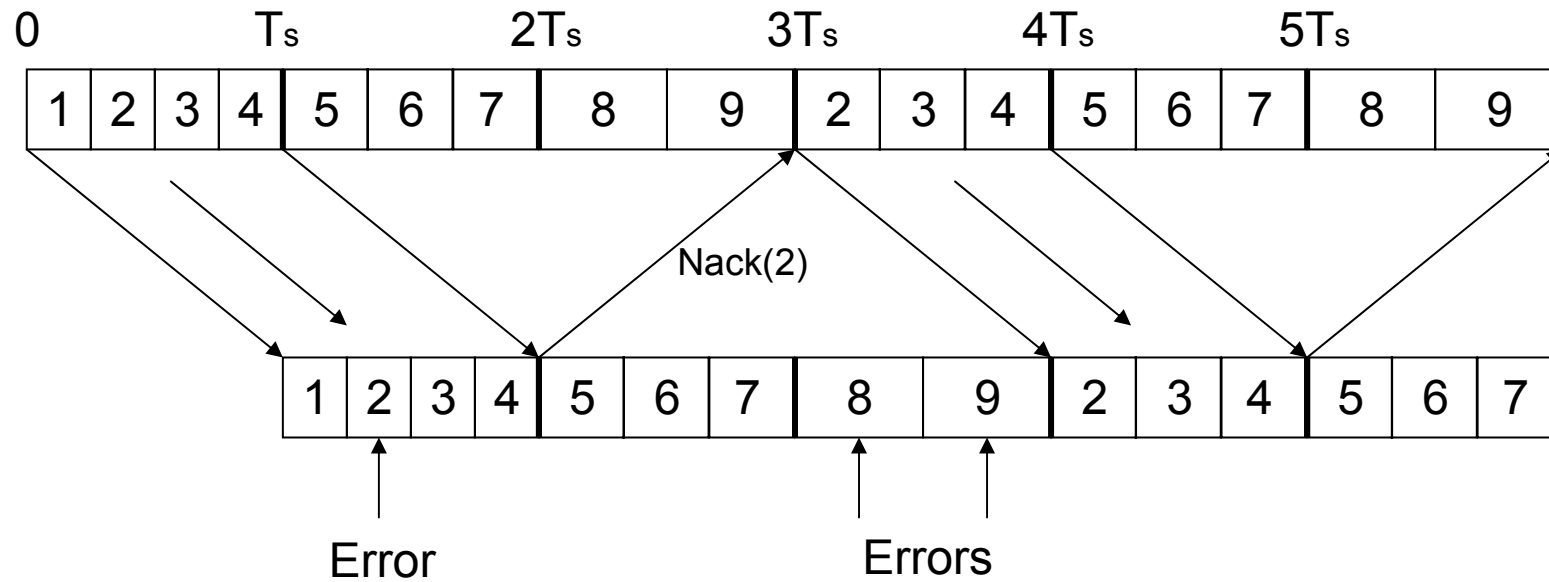
- Type-II Hybrid ARQ



AMC

- AMC - Adaptive Modulation and Coding
- Multi-rate transmission
- Adaptation to channel state
- Channel State Information is available at TX without delay
- Finite number of modes of operations

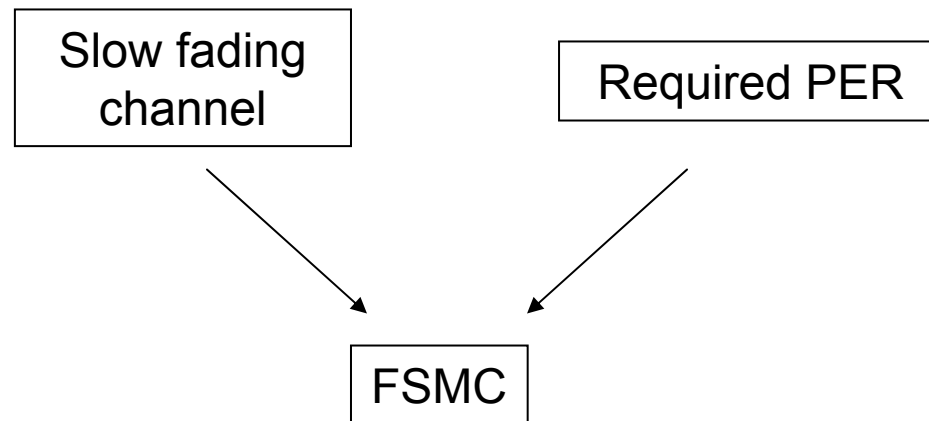
GbN ARQ



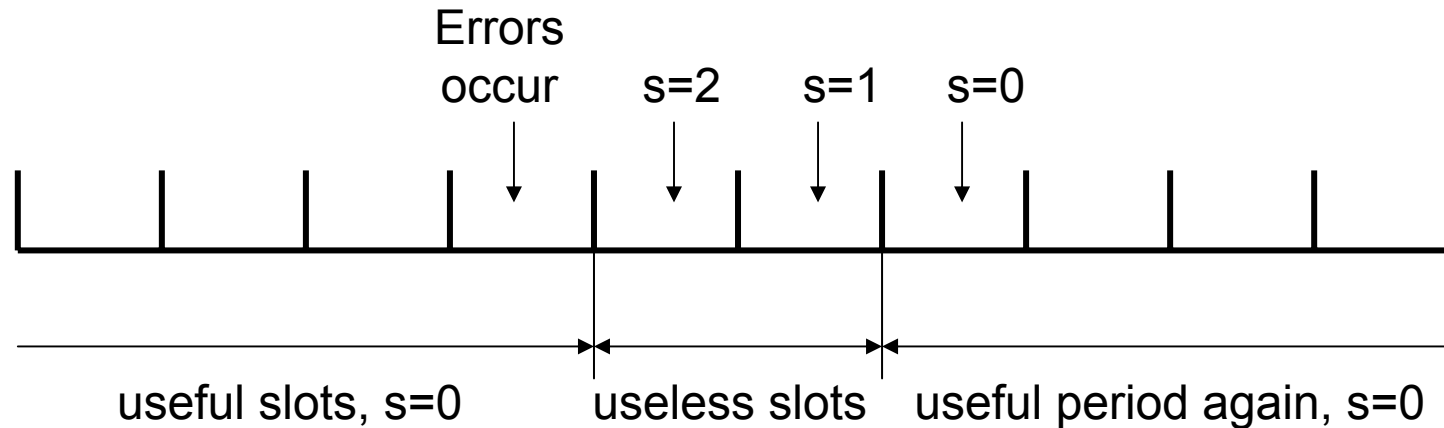
Rate: 4,3,2,3,3,2,...(packet/slot)

FSMC representation of wireless channel

- Slow fading channel
- SNR thresholds $S_0 (= 0) < S_1 < S_2 < \dots < S_k$



Queueing model for GbN



- $x(t)$ – number of packets in the system
- $s(t)$ – useful time slot track
- $c(t)$ – channel state
- $Z(t) = \{x(t), s(t), c(t)\}$ - 3-dimensional MC

Model analysis

Finite-state channel, AMC

Type-I HARQ

GBN-ARQ algorithm

Markov chain in Matrix representation

Matrix geometric analysis

Stationary distribution, π

Important system parameters: average queue length, average packet delay

Future work

- Obtain analytic(alternative) results
- Consider more complicated models
 - Finite number of retransmissions
 - Finite buffer length
 - Type-II Hybrid ARQ
 - Other ARQ algorithms

Thank you