Ministry of Communications
and Information Technology

PERFORMANCE ENHANCEMENT OF MTC IN LTE NETWORKS BY MAXIMIZING RANDOM ACCESS PROCEDURE THROUGHPUT

By:

Dr. Ibrahim Fayed

Dr. Eman S. El-Din

Contents

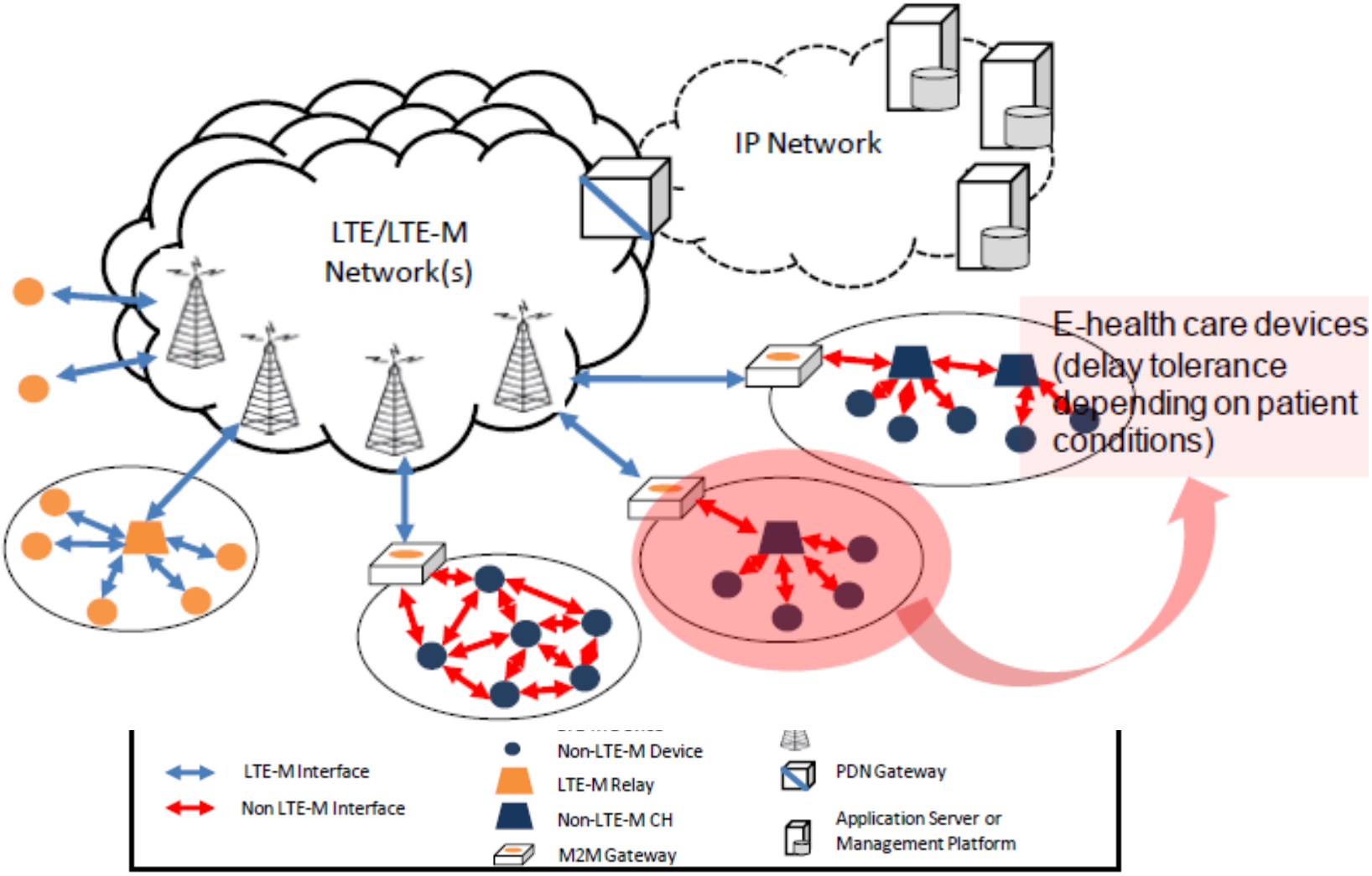
Introduction to Machine to Machine

-Machine-to-Machine(M2M) involves communication without (or only limited)human intervention

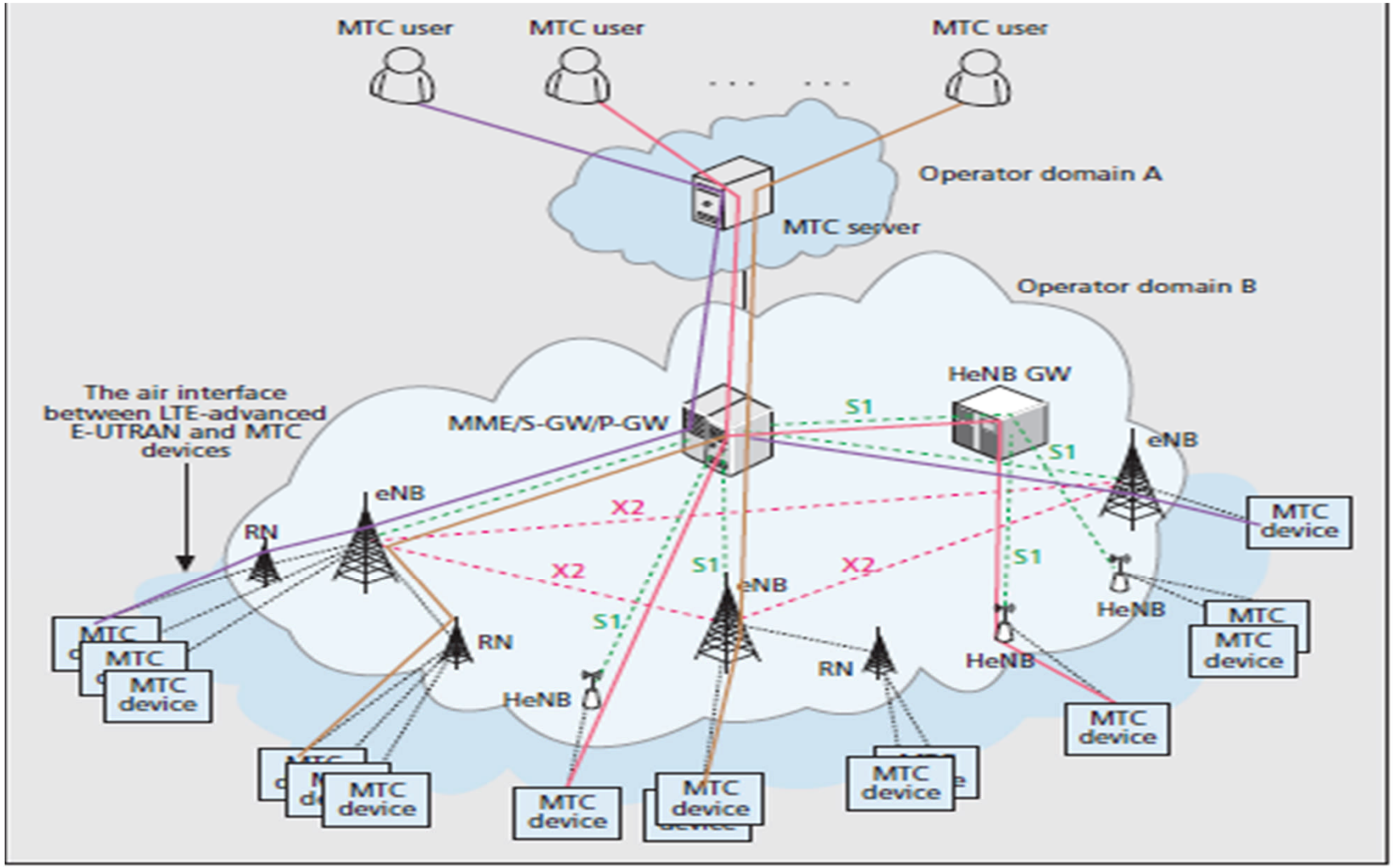
-The human is not the input, but only (optionally) the out put

-Also named Machine Type Communication (MTC) in 3GPP

M2M Applications

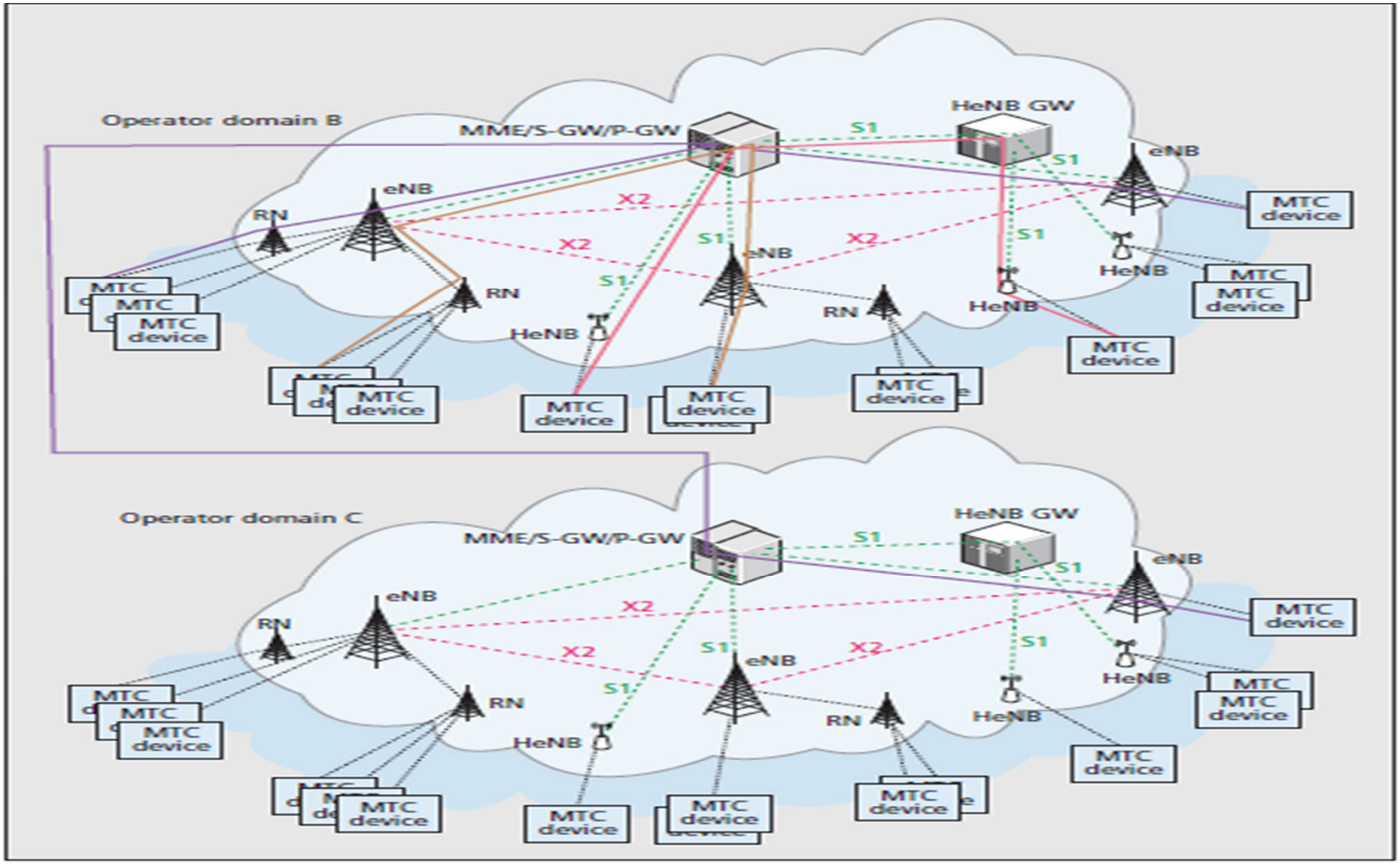


M2M Network Architecture-scenario1 With MTC Server



Toward Ubiquitous Massive Accesses in 3GPPMachine-to-Machine Communications IEEE Communications Magazine • April 2011

M2M Network architecture-scenario2 without MTC Server

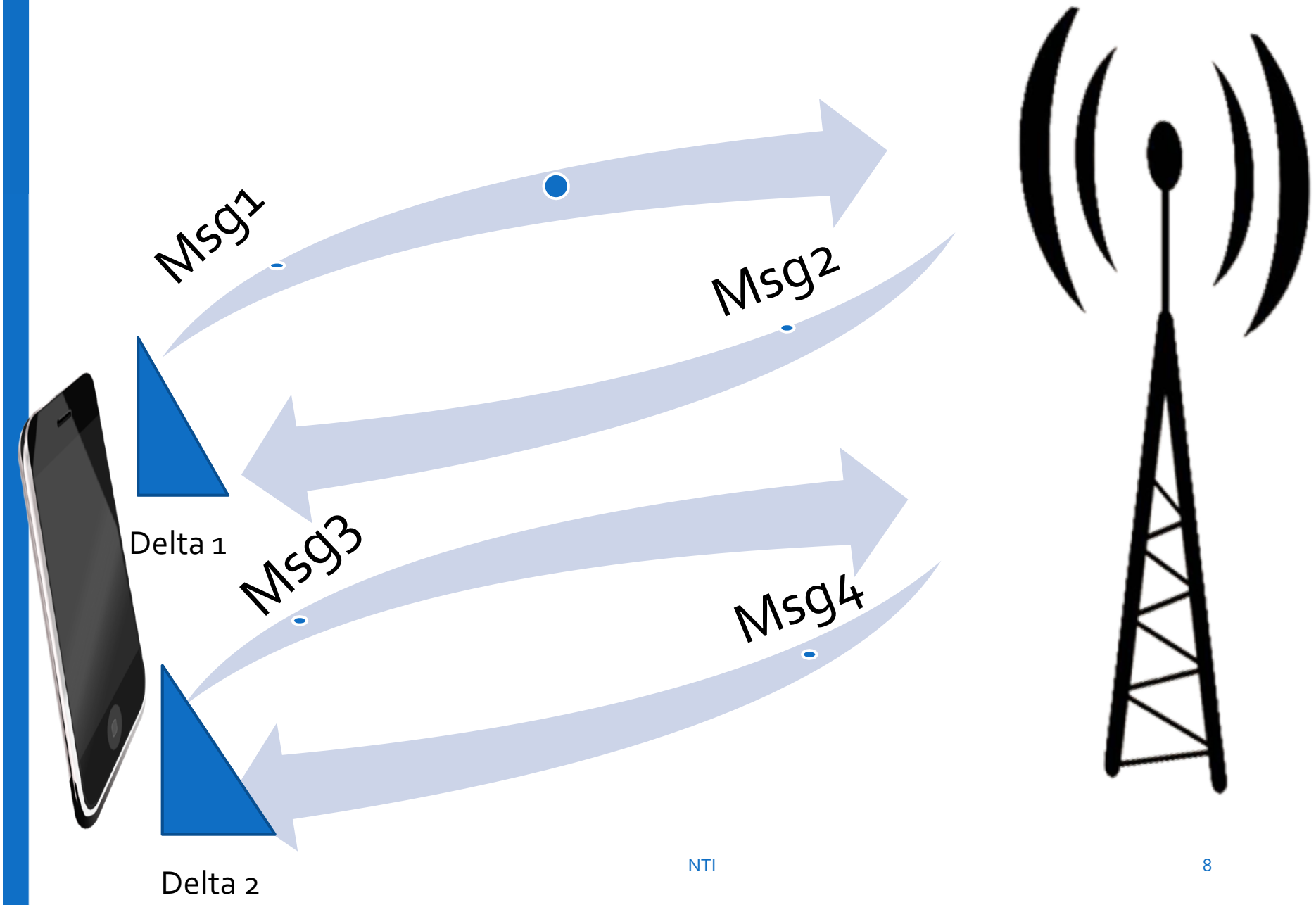


Toward Ubiquitous Massive Accesses in 3GPPMachine-to-Machine Communications IEEE Communications Magazine • April 2011

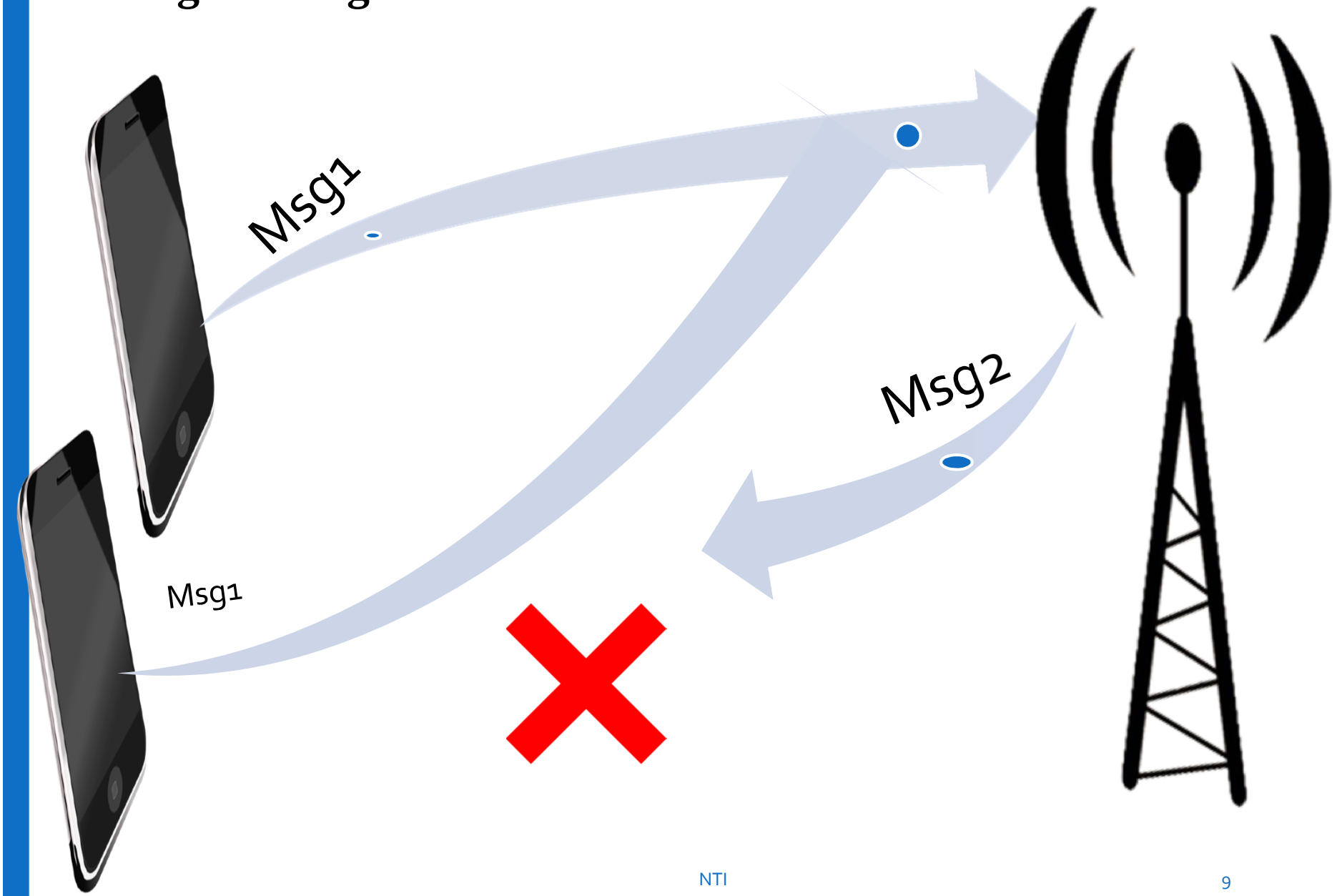
Problem Definition:

- Overload in access channel due to congestion in accessing the network (RACH procedure)
- A collision happens if two or more UEs take the same preamble in the same subframe.

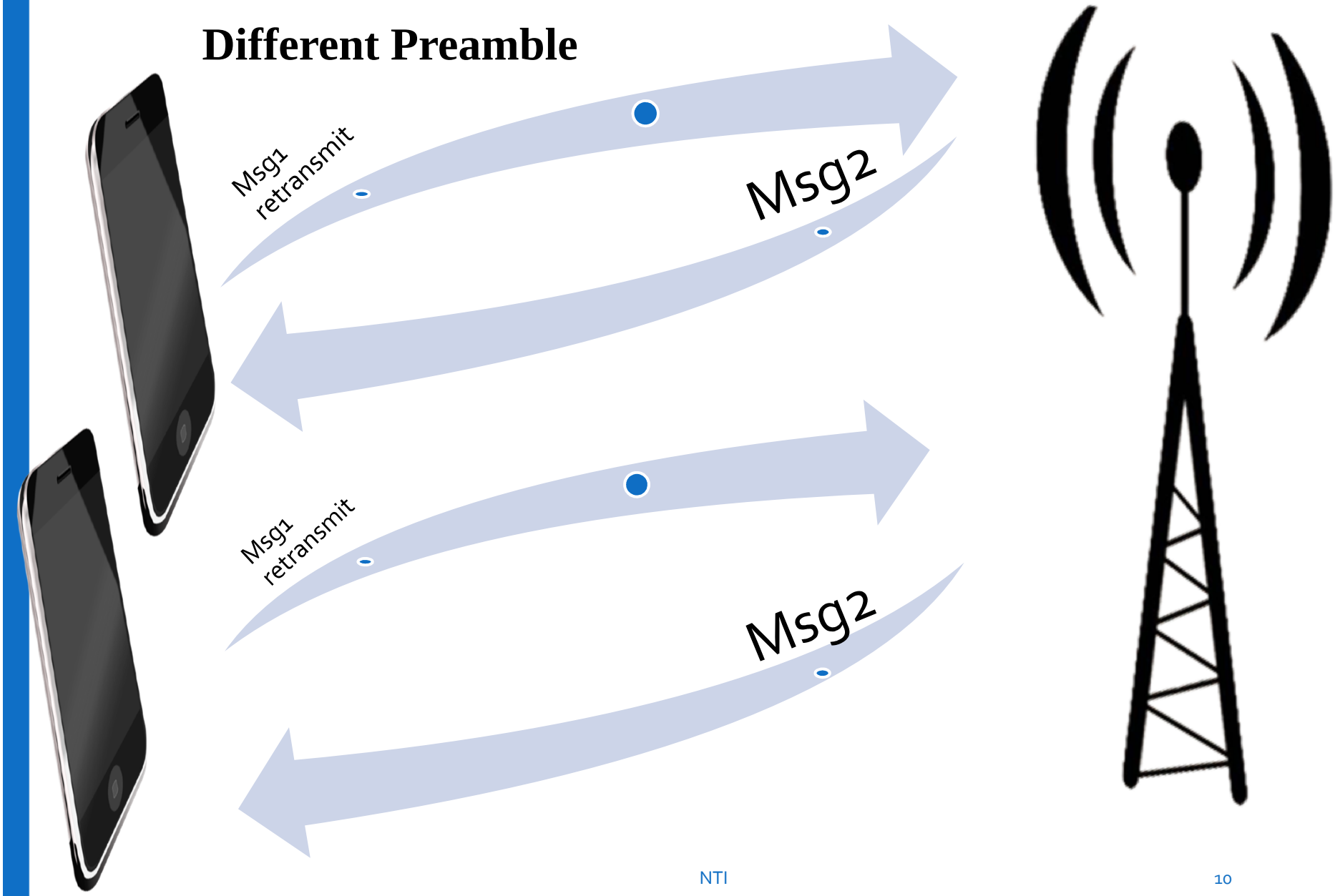
RACH PROCEDURE SUCCESS



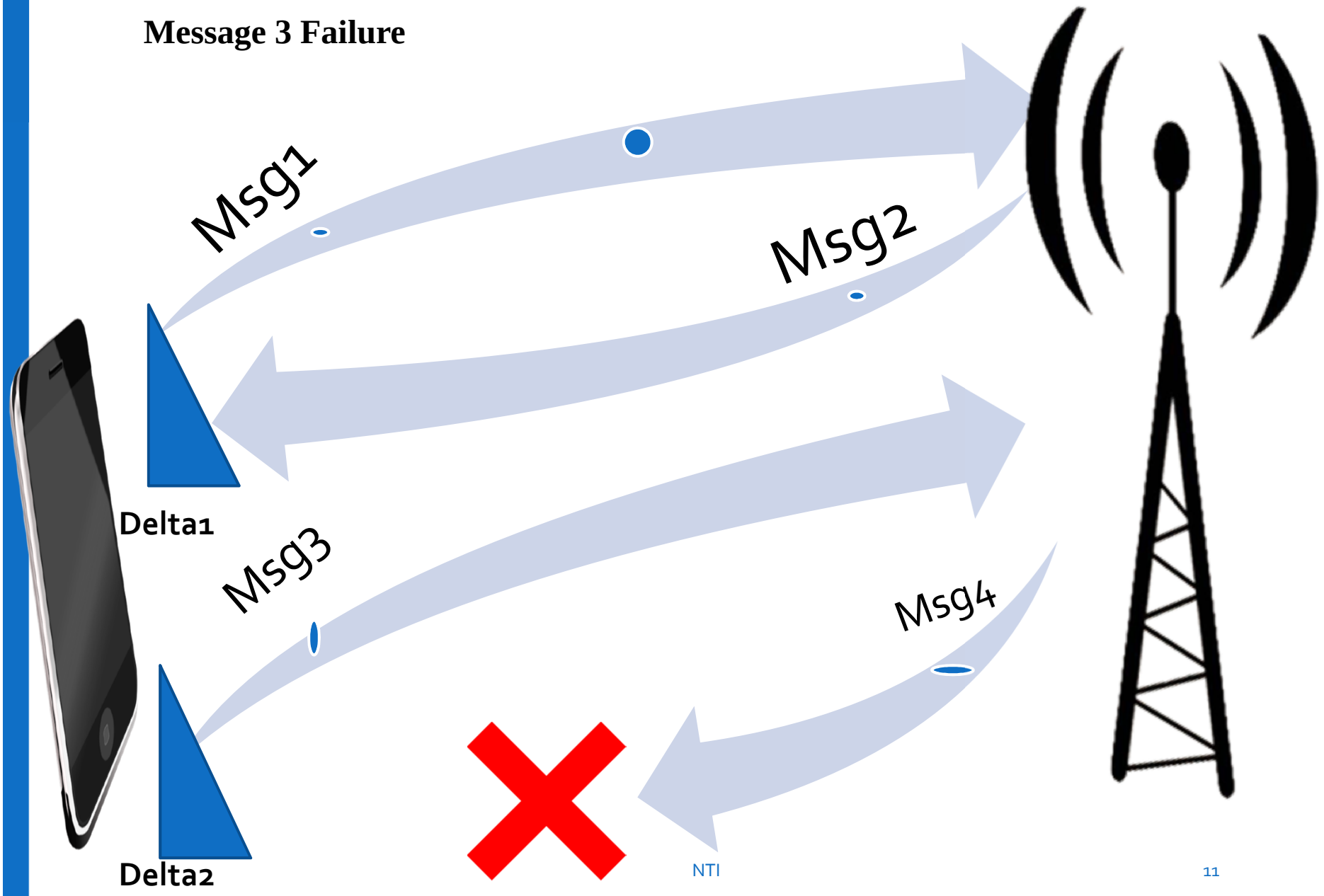
Message 1 Congestion



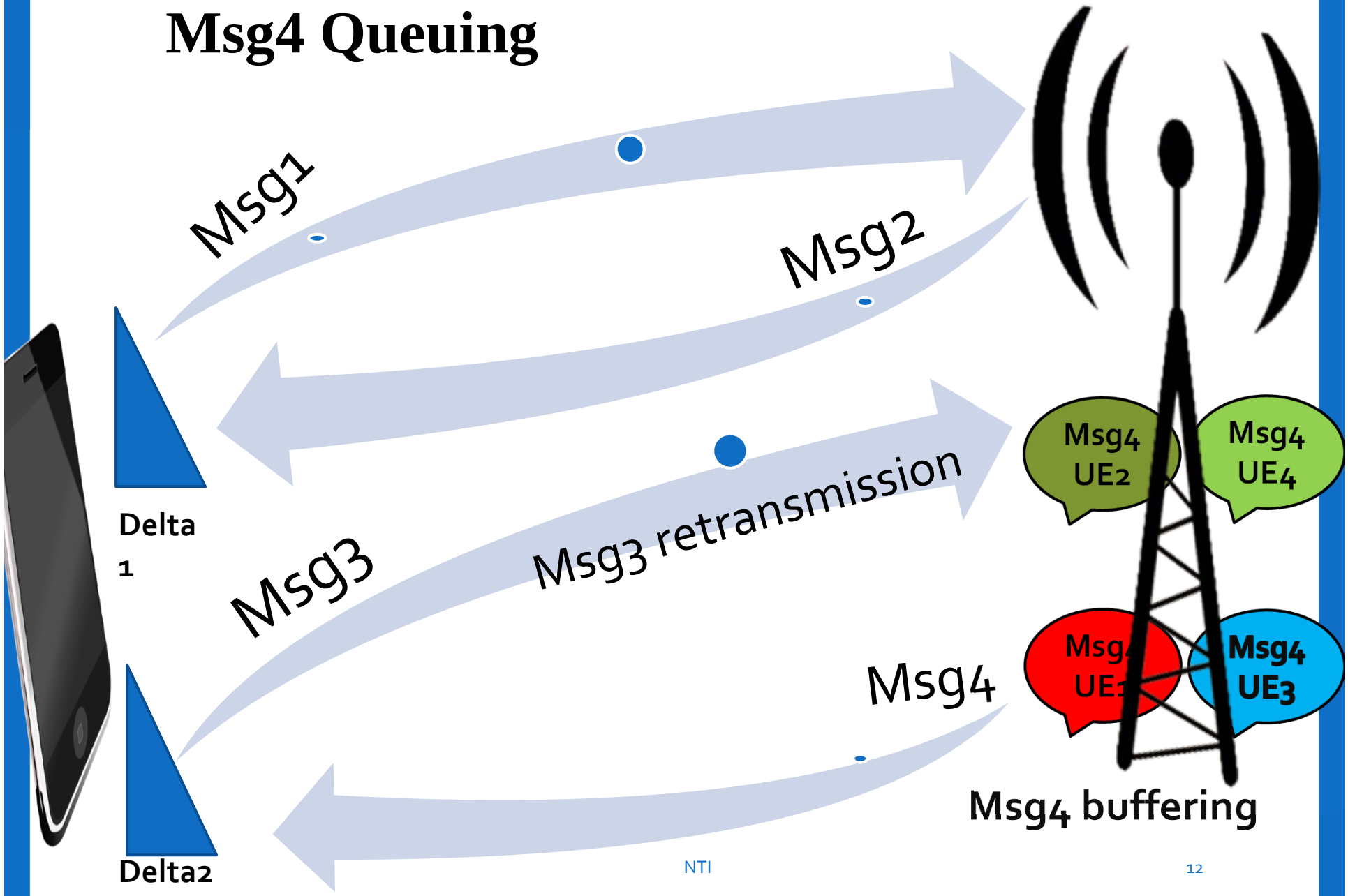
Different Preamble



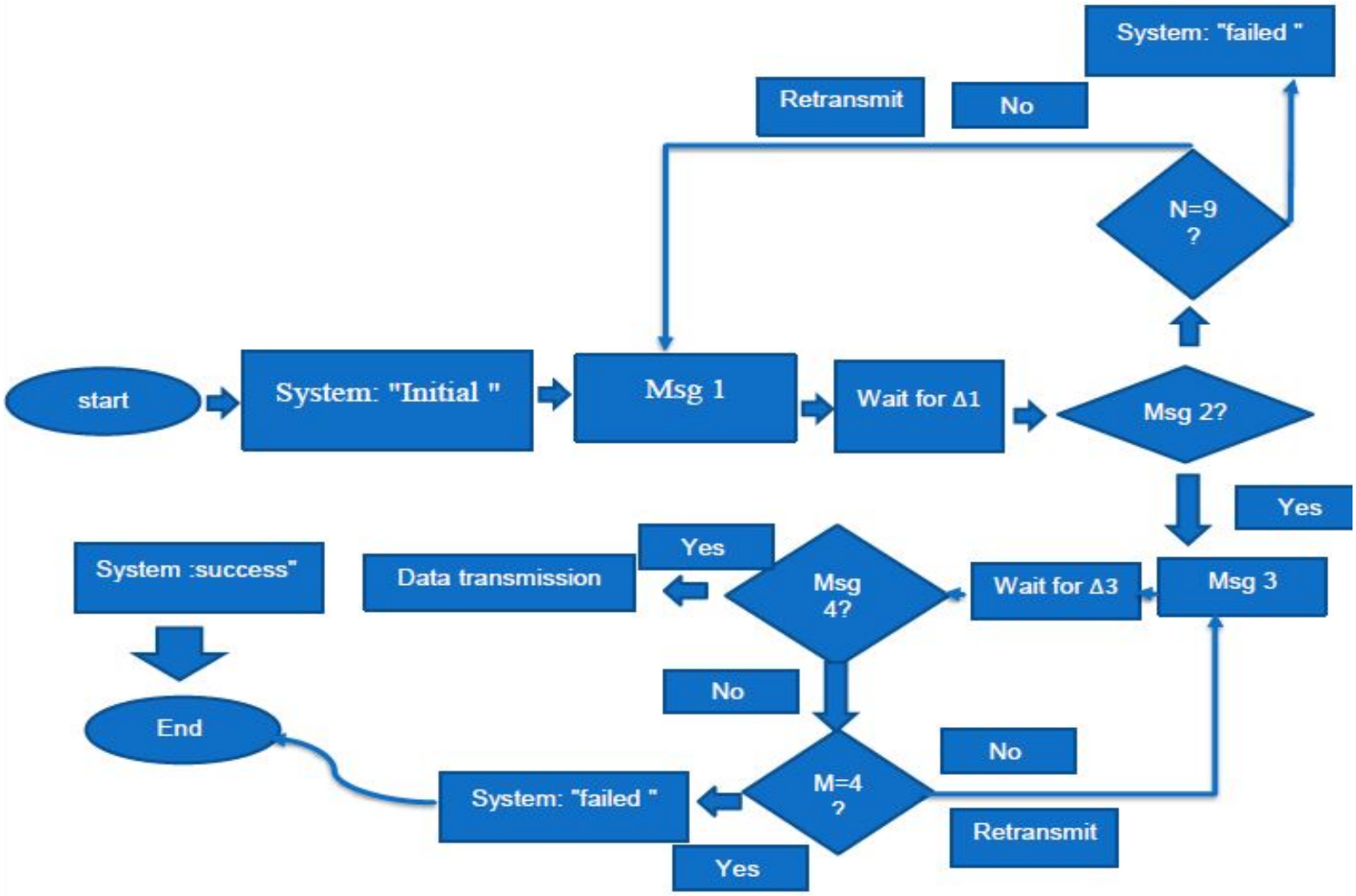
Message 3 Failure



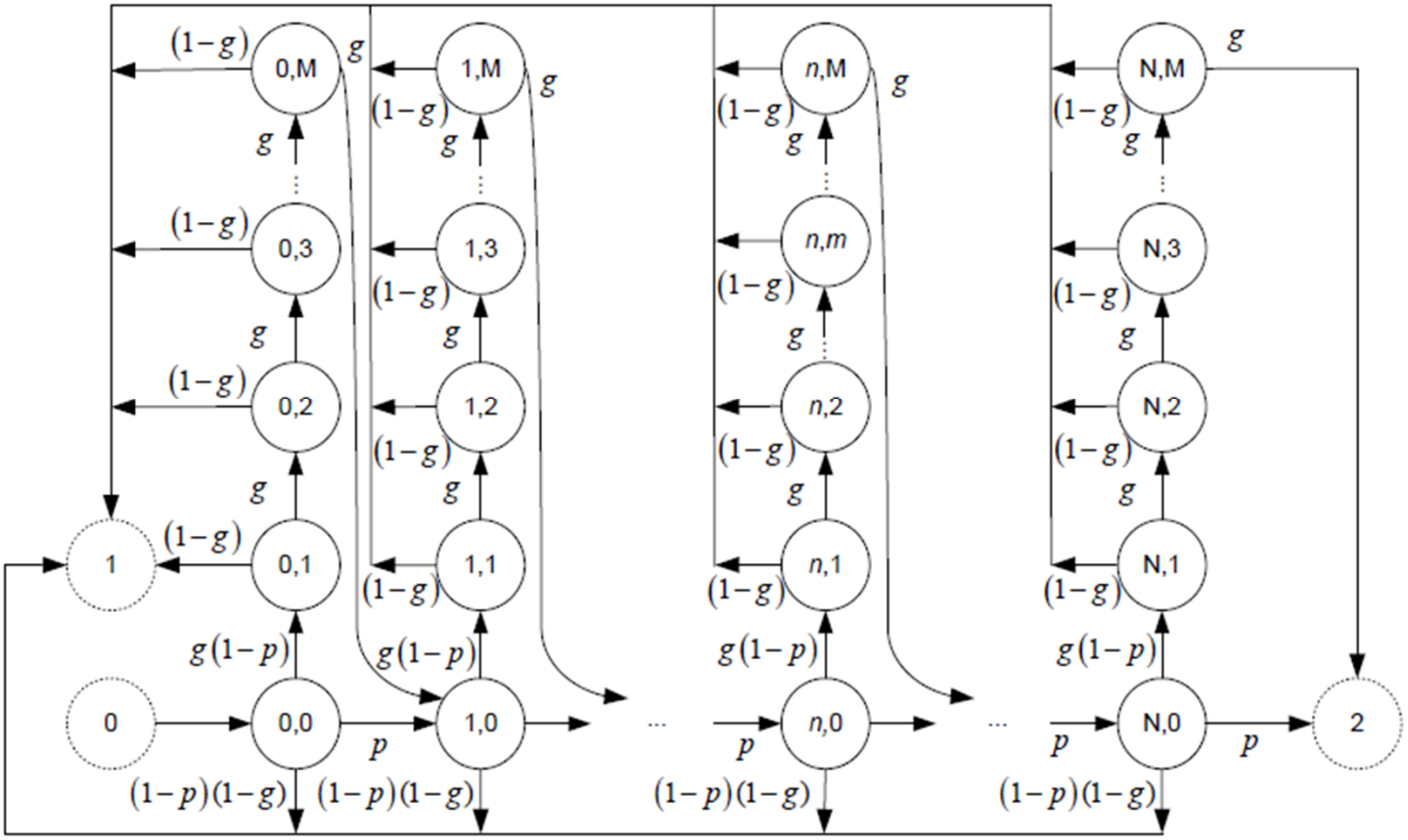
Msg4 Queuing



Model Flow Chart



State Transitioning Diagram



$$P_{total} = (1-p)(1-g)p^n g^m$$

Total Probability of Failure

- Total Probability of Failure

$$P_{total} = (1-p)(1-g)p^n g^m$$

- P : probability of collision in msg1 (same preamble transmitted twice simultaneously)
- g: probability of collision in msg3/4
- n:number of states to retransmit msg 1
- m: number of states to retransmit msg 3

Parameters .

Symbol	parameter	Typical Values
K	Number of preambles	54
b	RACH Periodicity	5
c	Max number of UL grants per subframe	3

From "Analysis of PDCCH Performance for M2M Traffic in LTE"
by Prajwal Osti, Pasi Lassila, Samuli Aalto, Anna Larmo, and Tuomas Tirronen
November 6, 2014.

Assumptions :

- To simplify the analysis, we assume that no other traffic, except this random access traffic, is present in the network
- *All* random access requests together (not only the fresh ones but also the retransmissions) constitute a Poisson process, the rate of which is denoted *a* (attempts per subframe).
- Distribution of users in network follows Uniform distribution

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MATHIMATICAL MODEL

- $P_i(a) = P_r\{A_{nk}=i\}=\frac{\left(\frac{ab}{k}\right)^i}{i!}e^{-ab/K}$
- $q_{ij}^{(1)}(a) := \mathbf{Pr}\{Y_n^{(1)} = i, , Y_n^{\sim(2)}=j\}=\binom{K}{i\ j-i} p_o^{K-J} p_1^i (1-p_o-p_1)^{j-i} 0 \le i \le j \le K$

- $q_{ij}^{(2)}(a):=Pr\{Y_n^{(2)}=i, Y_n^{\approx(2)}=j\}$

$$=\begin{cases} q_{ij}^{(1)}(a) & 0 \le i \le j \le bc \\ \sum_{k=bc}^{K} \sum_{l=i}^{k} q_{lk}^{(1)}(a) \frac{\binom{l}{i}\binom{k-l}{bc-i}}{\binom{k}{bc}} & 0 \le i \le\le j = bc \end{cases}$$

From "Analysis of PDCCH Performance for M2M Traffic in LTE"
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CONT.

- $\boldsymbol{q_i^{(2)}(a) := \Pr\{\{Y_n^{(2)}=i\}\sum_{j=i}^{bc} q_{ij}^{(2)}(a)}$ $\qquad \boldsymbol{0 \le i \le bc}$

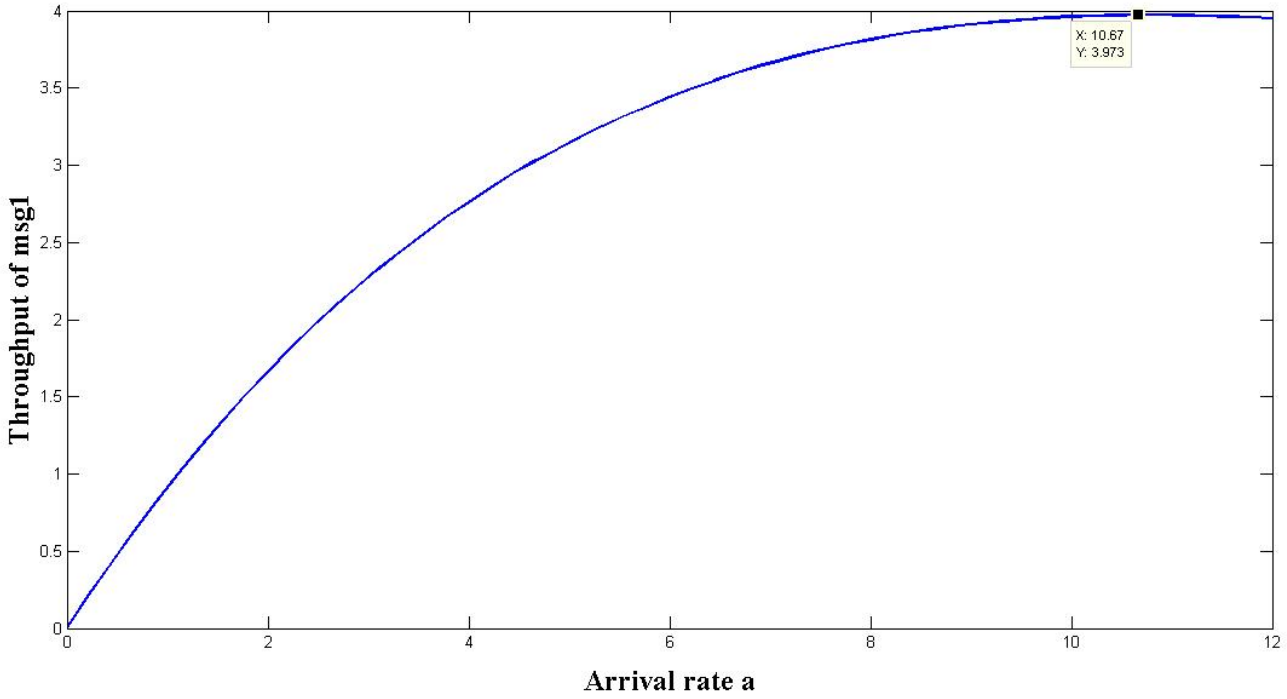
- $\theta^{(1)}(a) = \frac{E[Y_n^{(1)}]}{b} = ae^{-ab/K}$

- $\theta^{(2)}(a) = \frac{E[Y_n^{(2)}]}{b} = \frac{1}{b}\sum_{i=1}^{bc} iq_i^{(2)}(a)$

Results and analysis
Throughput of Msg 1

Our results

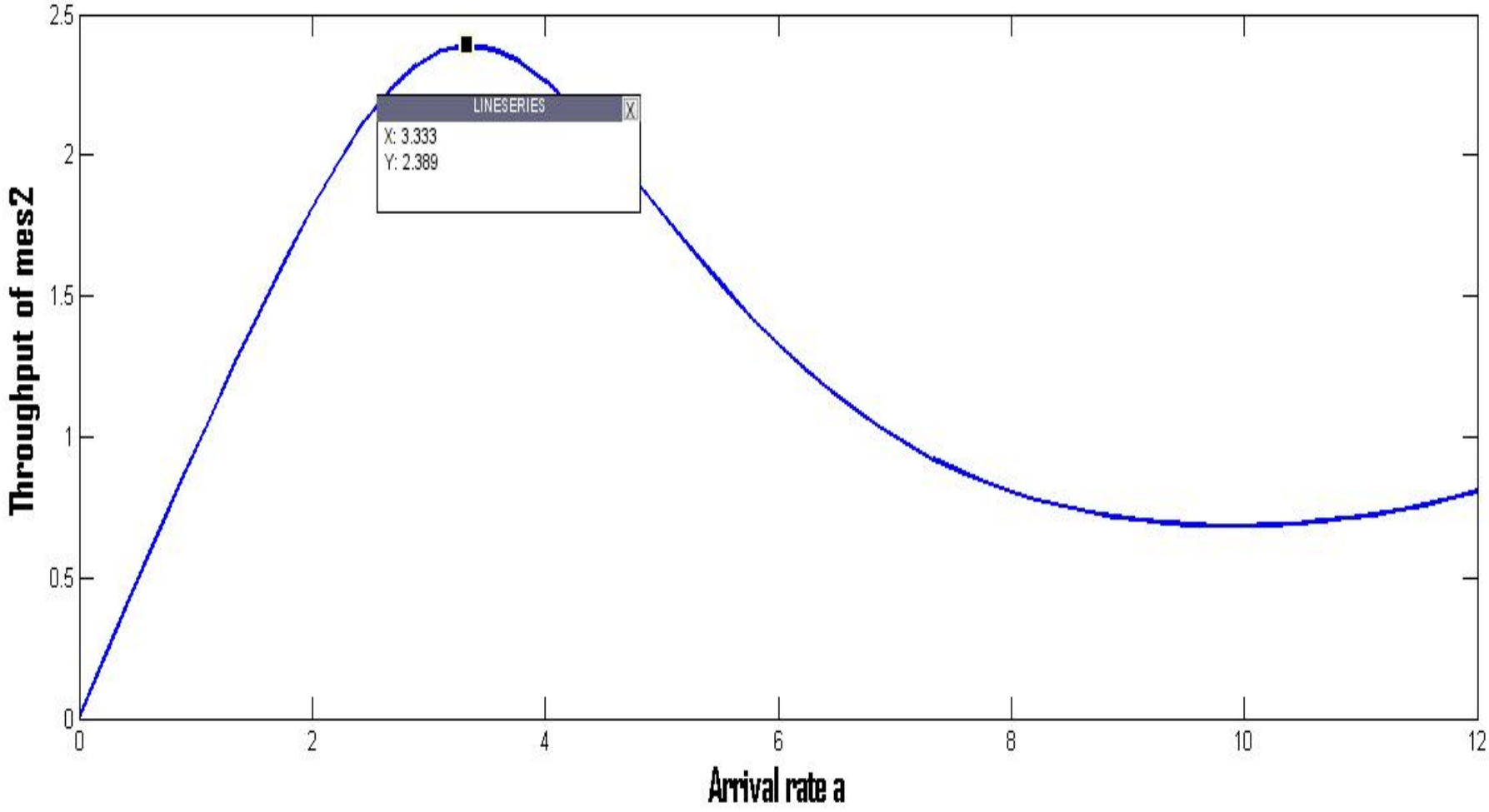
$\max_a \theta^{(1)}(a) = 3.973 \ requests/ms$



Throughput of Msg 2

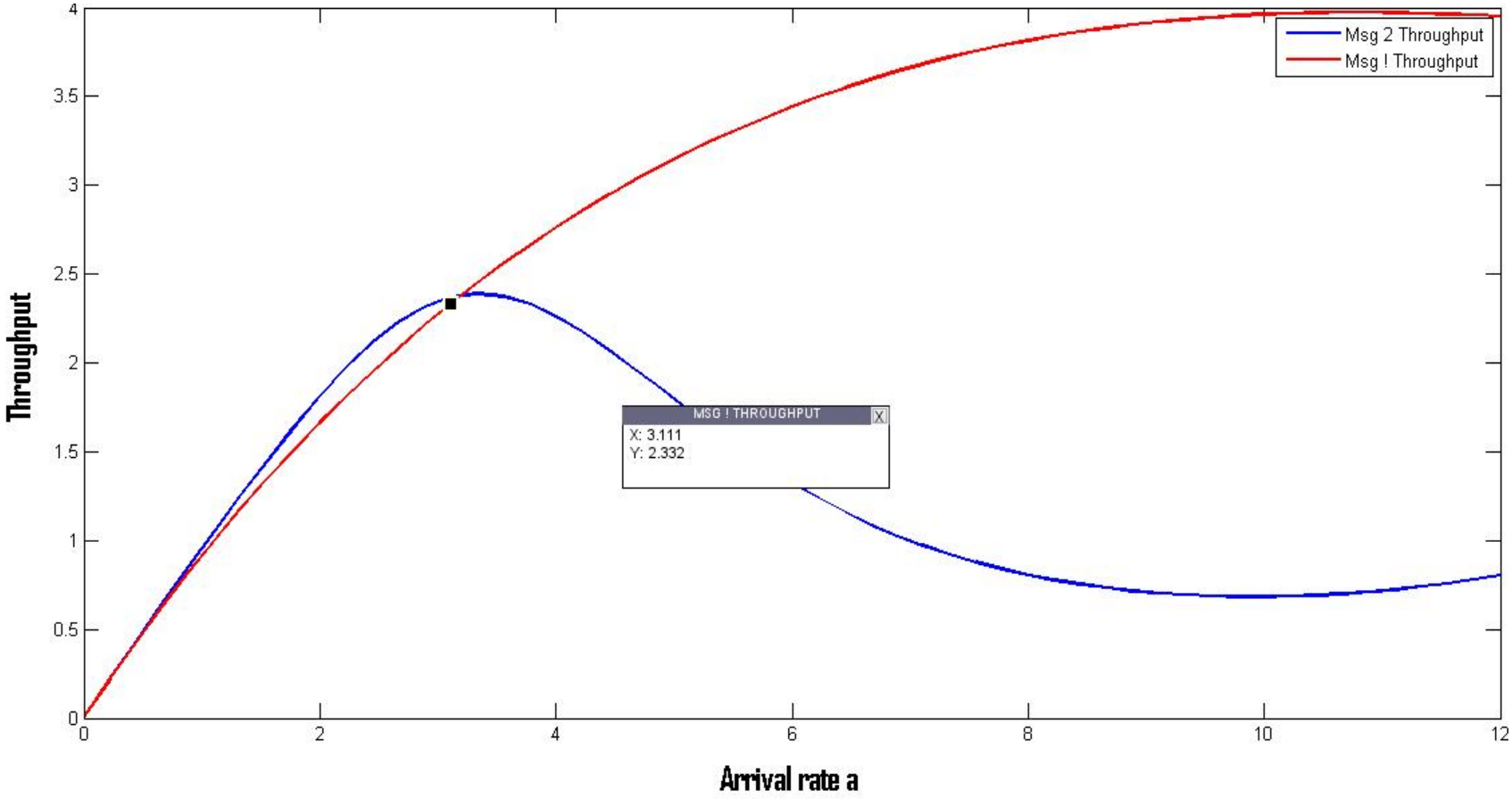
Our results

$\max_a \theta^{(2)}(a) = 2.377\, requests/ms$



Throughput of Msg 1& Msg 2

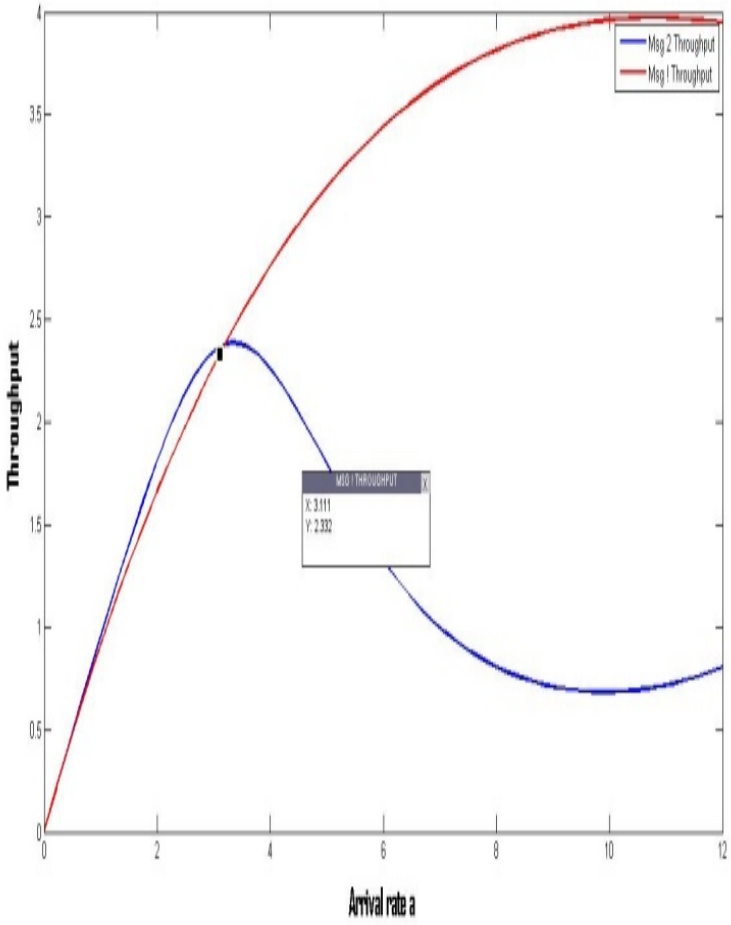
Our results $\theta^* = 2.332$

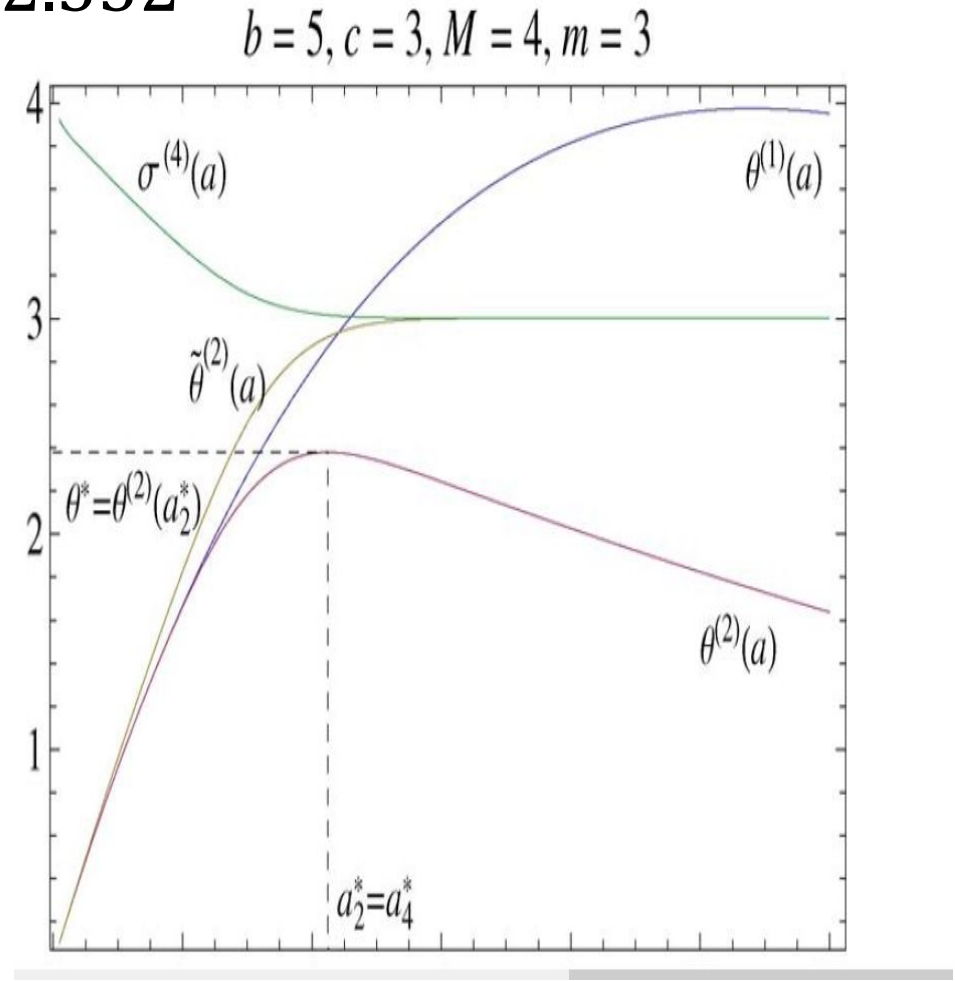


Verification

b=5, c=3,M=4,M=3

$\theta^* = 2.332$





"Analysis of PDCCH Performance for M2M Traffic in LTE"
Osti, Pasi Lassila, Samuli Aalto, Anna Larmo, and Tuomas Tirronen November 6, 2014

Future work

- Traffic pattern analysis based on bandwidth consumption (ex: queuing for PDCCH & its impacts on throughput)
- Multi hop connections between eNBs unlike single hop H2H communication.
- Security to maintain data integrity by protecting from potential hackers
- Promising solution for the air interface of general M2M communications may lie in the cognitive radio technology to reuse licensed spectrum

Thank you