An Architecture for Distributed Source Localization in Wireless Sensor Network

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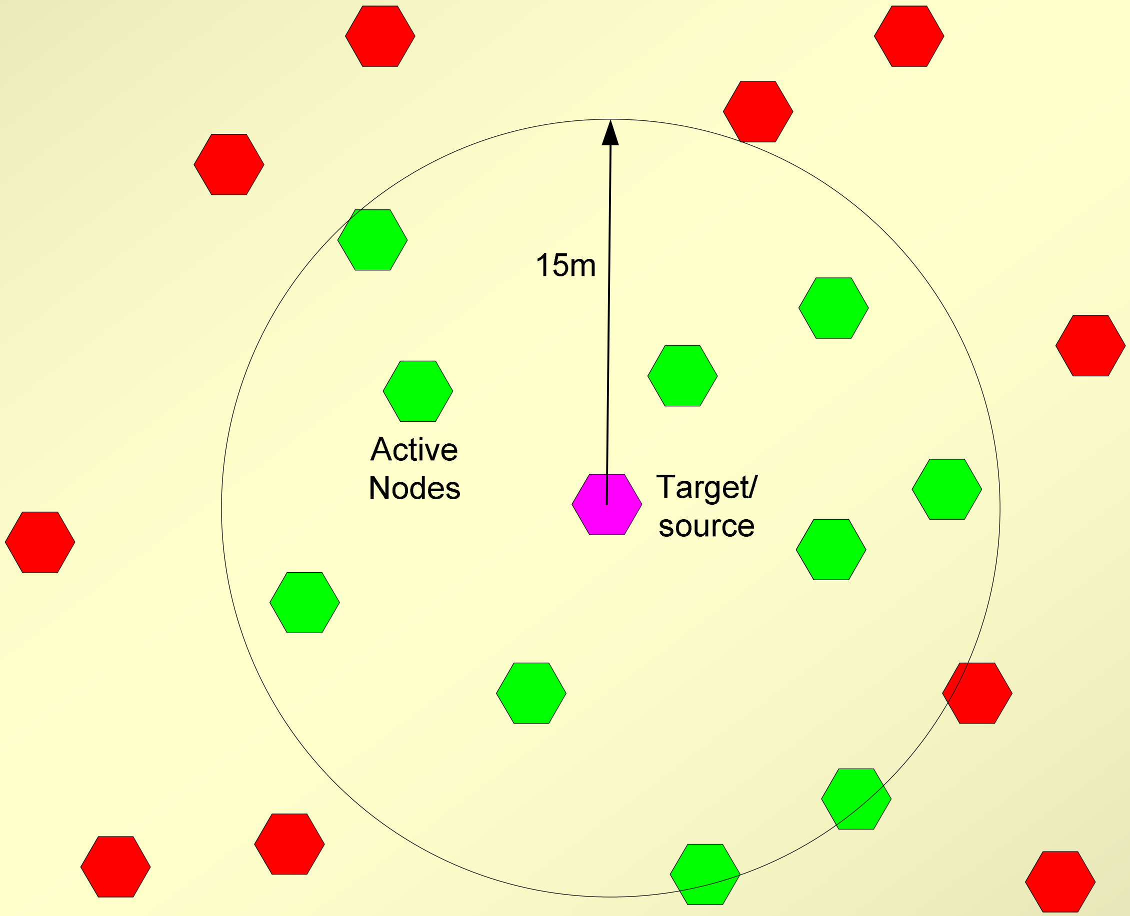
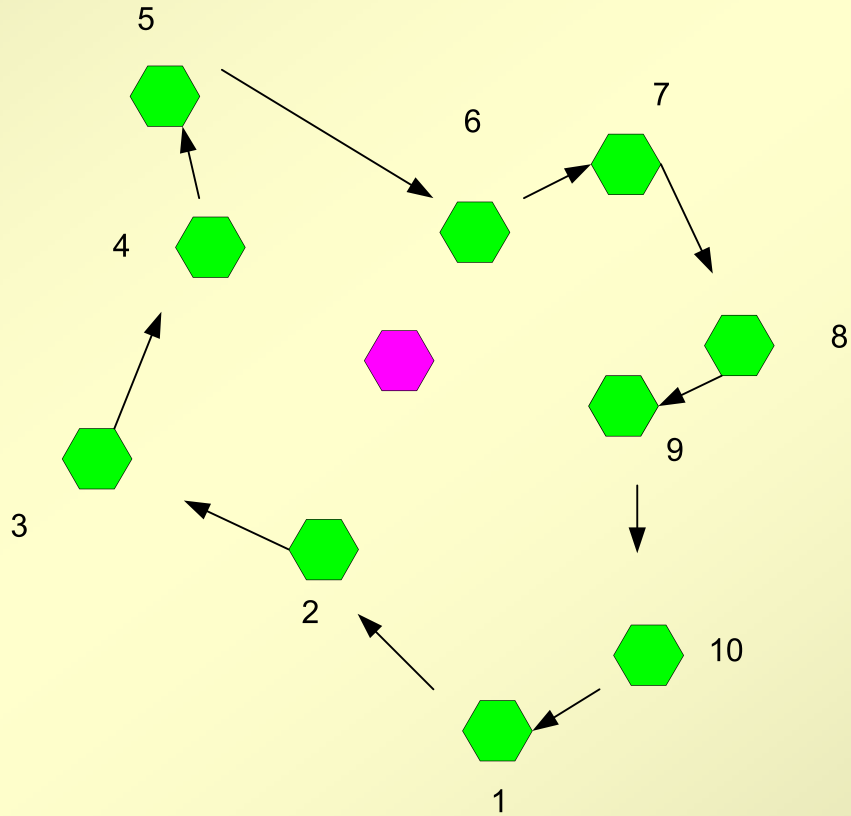
Problem:	Estimate the location of a moving source using sensor networks
Solution:	
Algorithms:	Collaborative signal processing (CSP)
Recent advancements:	Incremental non-linear Optimization for use with distributed/ decentralized CSP (1996, 2004)
Architecture:	Topic of this presentation
Literature:	Numerous *incoherent* protocols

Objective: Estimate the source/ target location



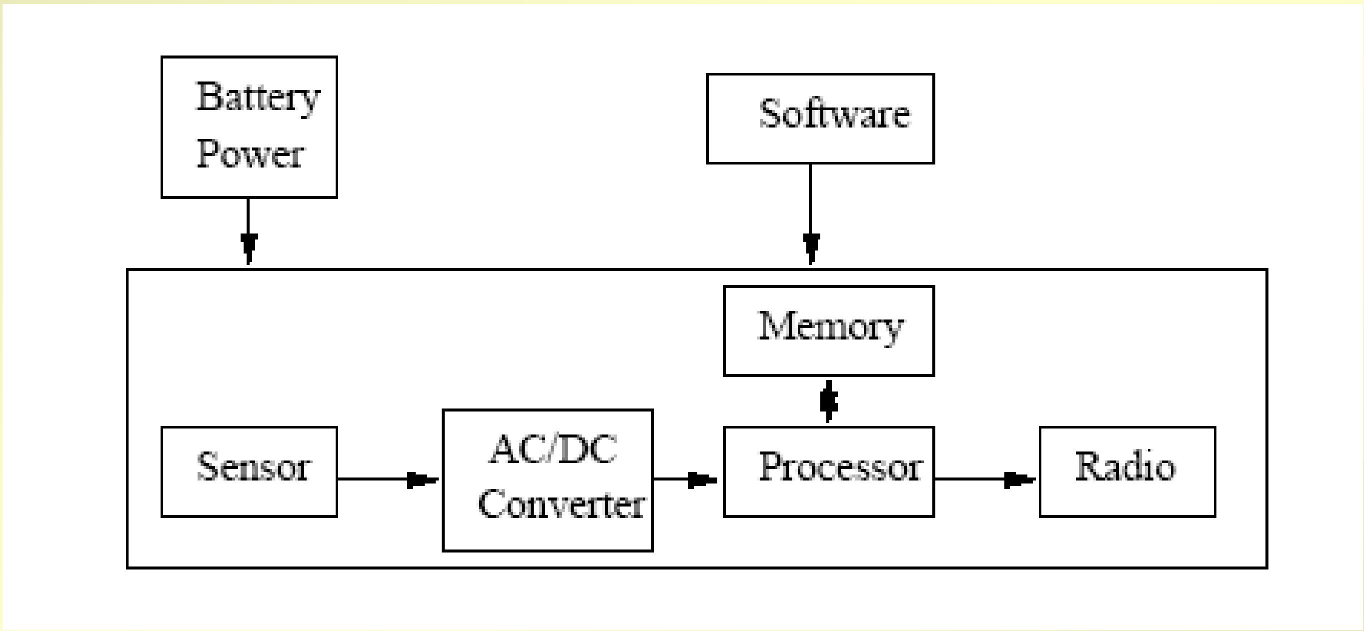
Objective: Estimate the source/ target location using

distributed CSP



Node-1 back to Node-1: thatz one cycle

Components


Battery Power
Software
Memory
Sensor
AC/DC Converter
Processor
Radio

Requirements (of the algorithm) to be met (by the architecture):

- Ad-hoc network
- Self-organizing MAC
- Scalable
- Node insertion (new node)
- Node deletion (node out-of-range)
- Directed graph (cyclical communication)

Pessimist's take!

- **Conserve energy**
- Bad nodes
- node mobility
- refresh a static network

NO SINGLE SOLUTION SATISFIES ALL

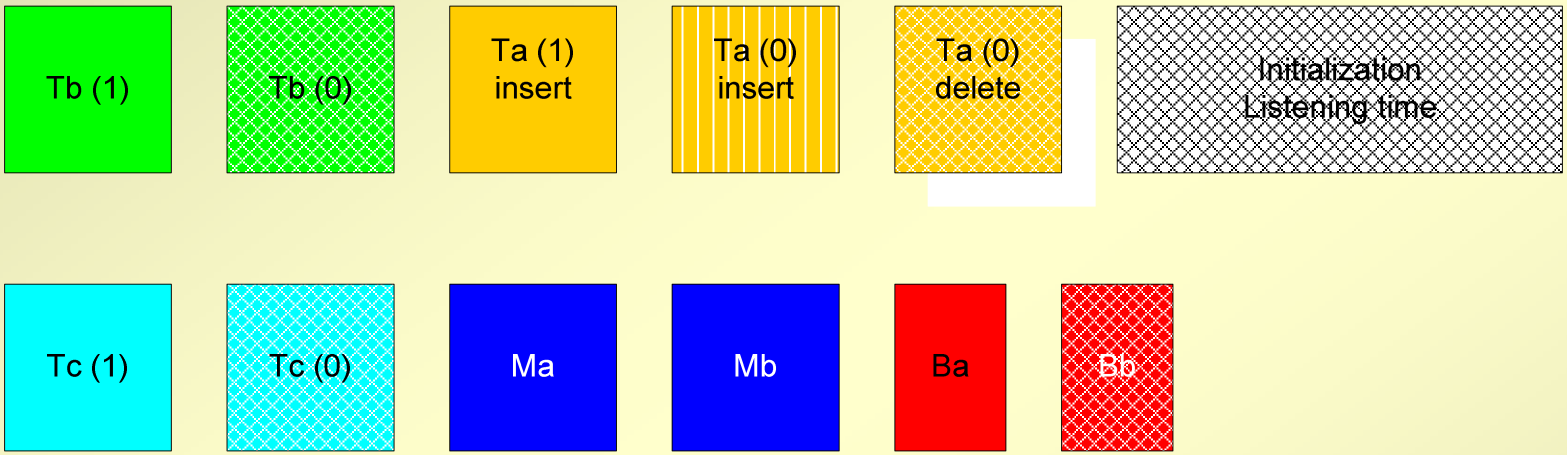
Assumptions:

- Absolute time synchronization
- Nodes aware of their locations
- Can simultaneously receive two frames operating in two bands

Risk factors:

- Absolute time synchronization: difficult in practice. As an example, USA's patriot missiles could not detect the Scud missiles launched by Iraq during Gulf-war just because the clocks were off by 1/3s which further resulted in estimating the target off by 600m
- The network formed may collapse if the initial link formed is too bad a guess
- If the source is moving too fast, latency in network formation may be counter-productive in the distributed CSP setting

Types of frames



Broadcast

- TYPE-a (ta)
- TYPE-b (tb)
- TYPE-c (tc)
- Beacon-a (ba)
- Beacon-b (bb)

Message

- message-a (ma)
- message-b (mb)

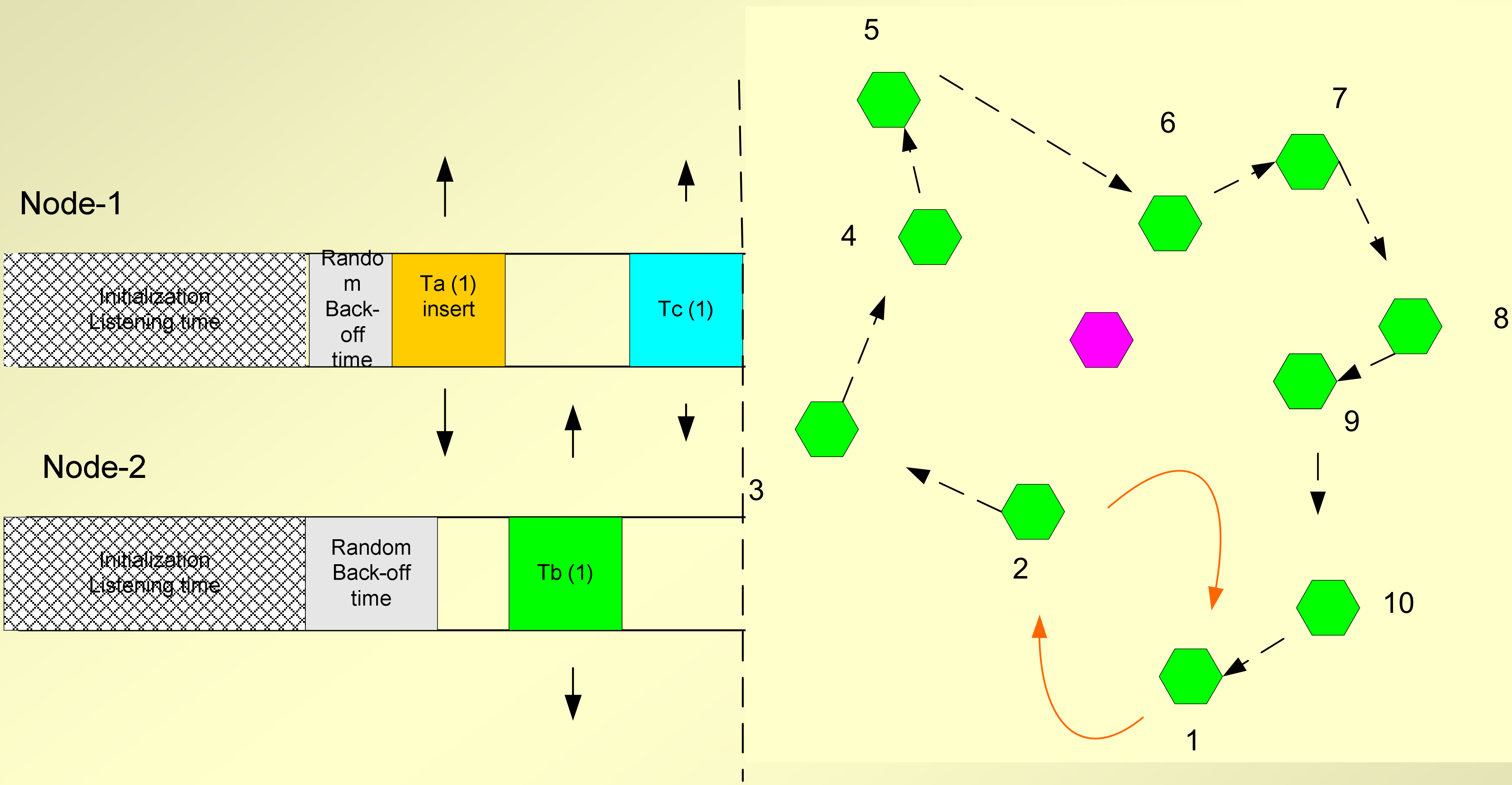
Parameters/ Variables

N: current number of sensors in the network
T_Tx: Transmisstion time
T_Rx: Reception time
T_rand_backoff_max: maximum backoff time
t_bkoff: random back-ff time
Counter_cycle: current cycle number
Counter_total_cycles: log2(N)
T_alg: algorithm time
T_initiaze: Initialization listening time

Frequency bands

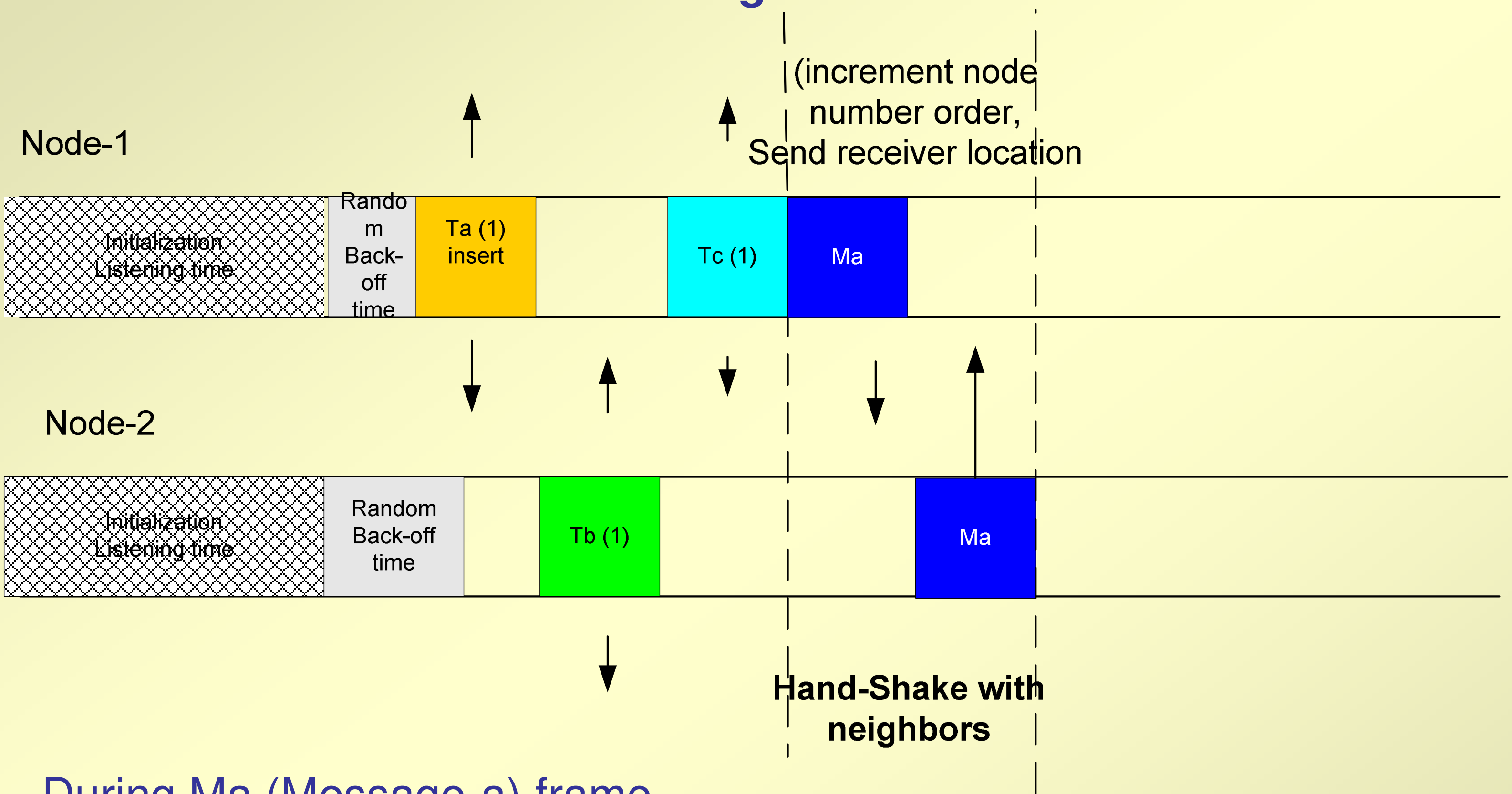
f_d: delete a node (used in ta)
f_i: insert a node (used in ta, tb and tc)
f_b: beacon frame
f_m: messege frame (used in ma,mb)

Very Initial Link formation



Node-1 and 2 establish
a link

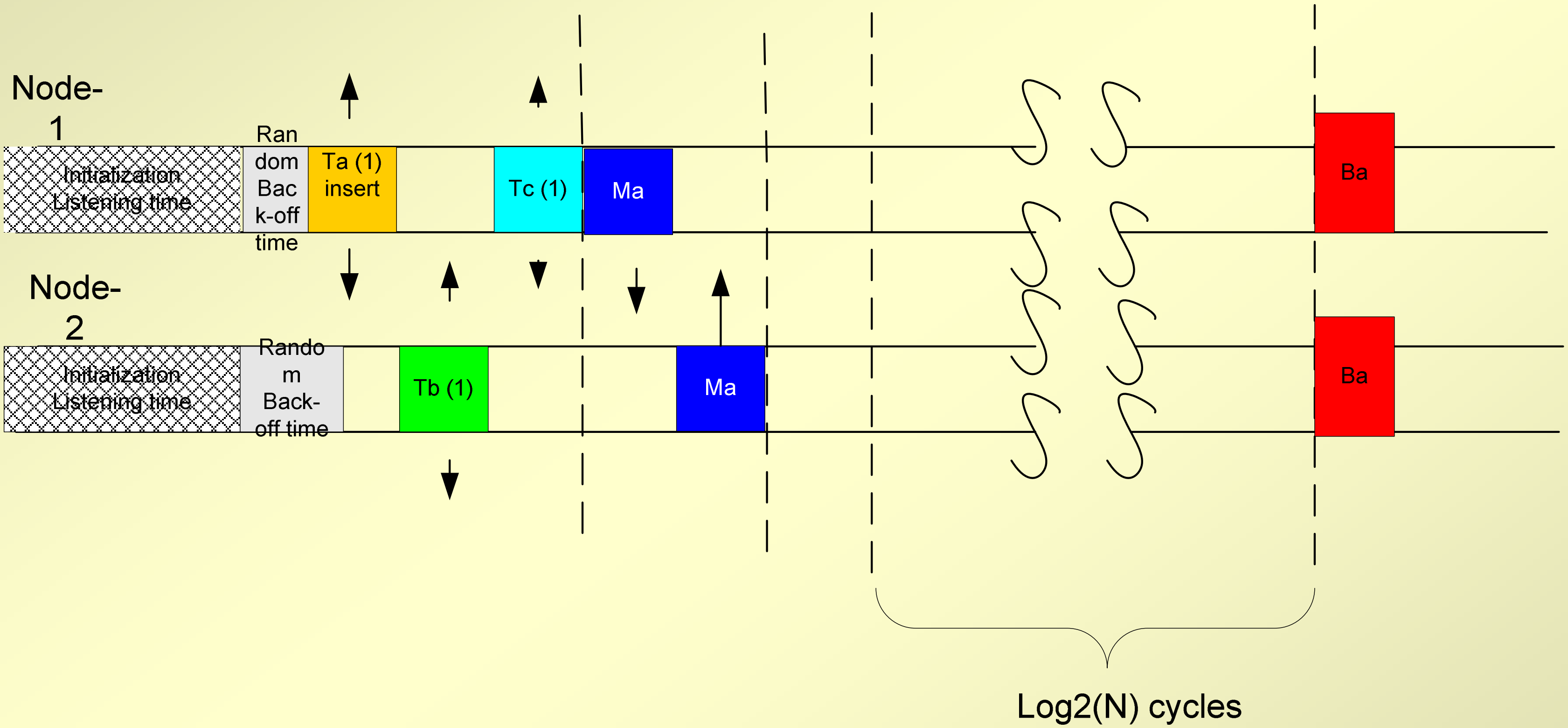
Information exchange in the new link



During Ma (Message-a) frame

- node number, intended receiver location and total number of nodes are transmitted
- Logical indeces are formed at the end of this cycle which helps in defining the TDMA slots

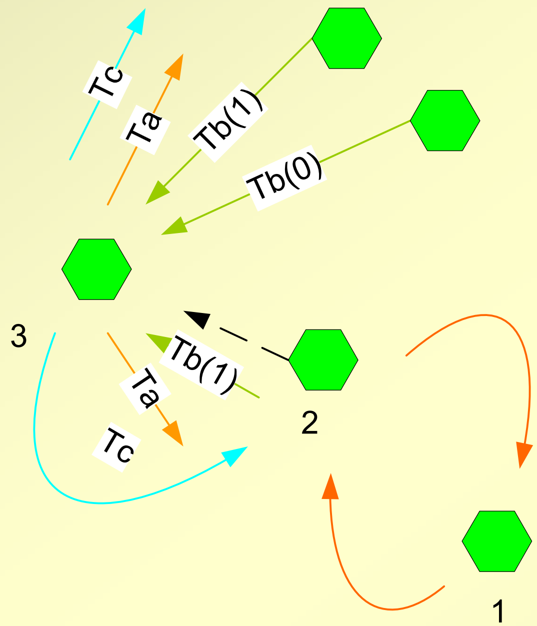
Network management phase begins to check for inserting new nodes or deleting nodes



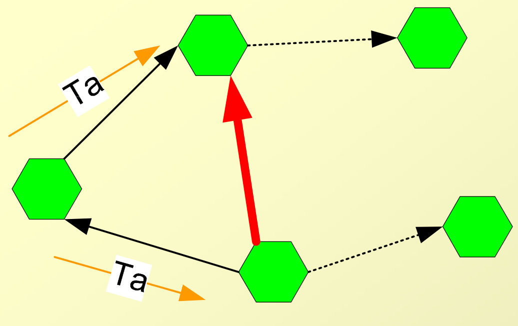
- At the end of beacon interval, nodes can send ta type frames
- The routing table is exactly like a linked-list except that it is maitained in pieces by all the nodes

Addition and Deletion of a node

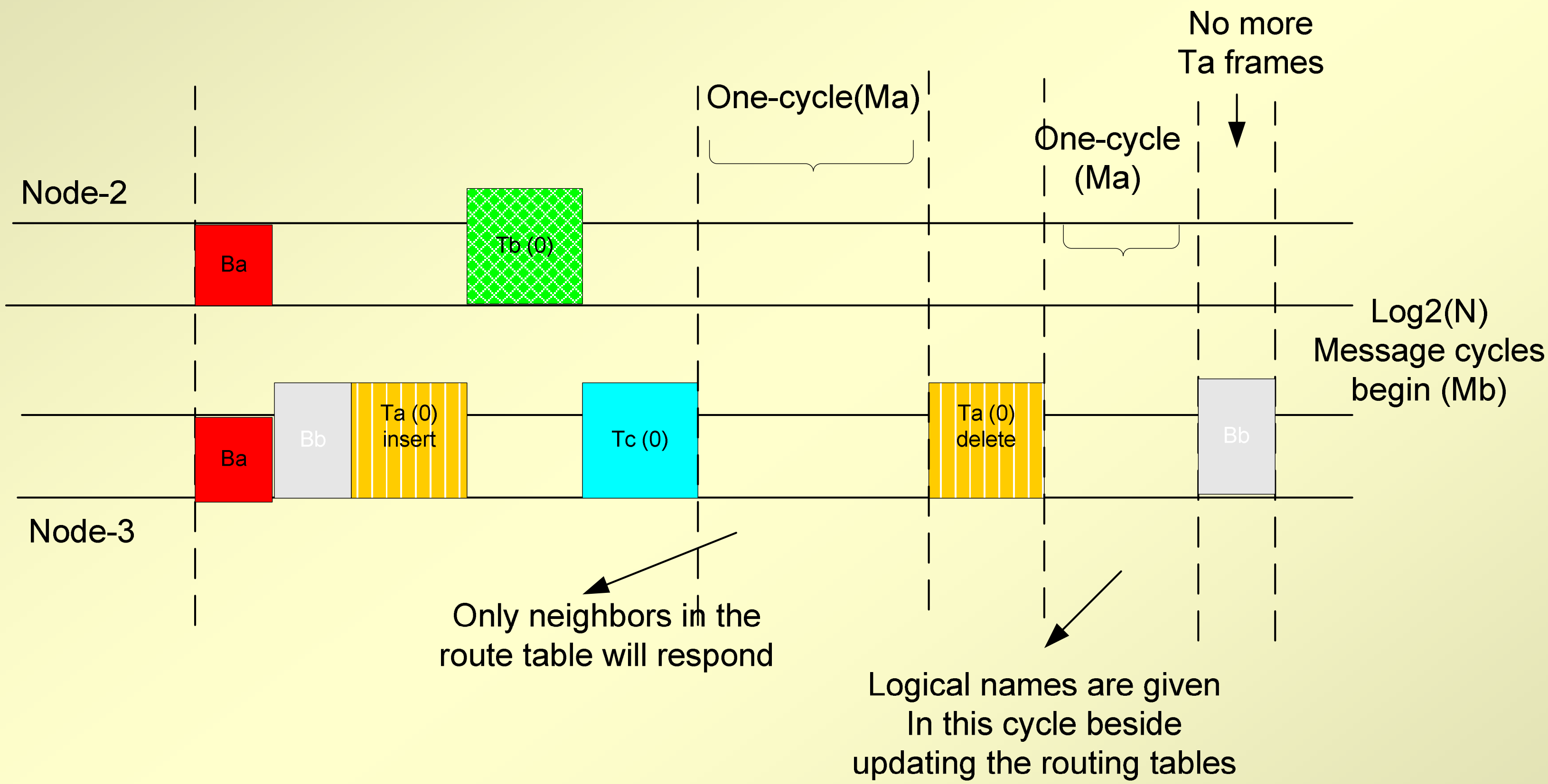
Adding a node



Deleting a node



Time-Diagram



Conclusions:

- meets “requirements”
- works under “assumptions”
- has “risks” associated with
- still evolving far away from implementation

Future course:

- define a software architecture for implementation
- and implement

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- and patient audience

References:

Soma Sekhar Dhavala, ee543x project report