Adding Disruption Tolerant Networking to UnetStack

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Agenda

Challenges in Underwater Networks

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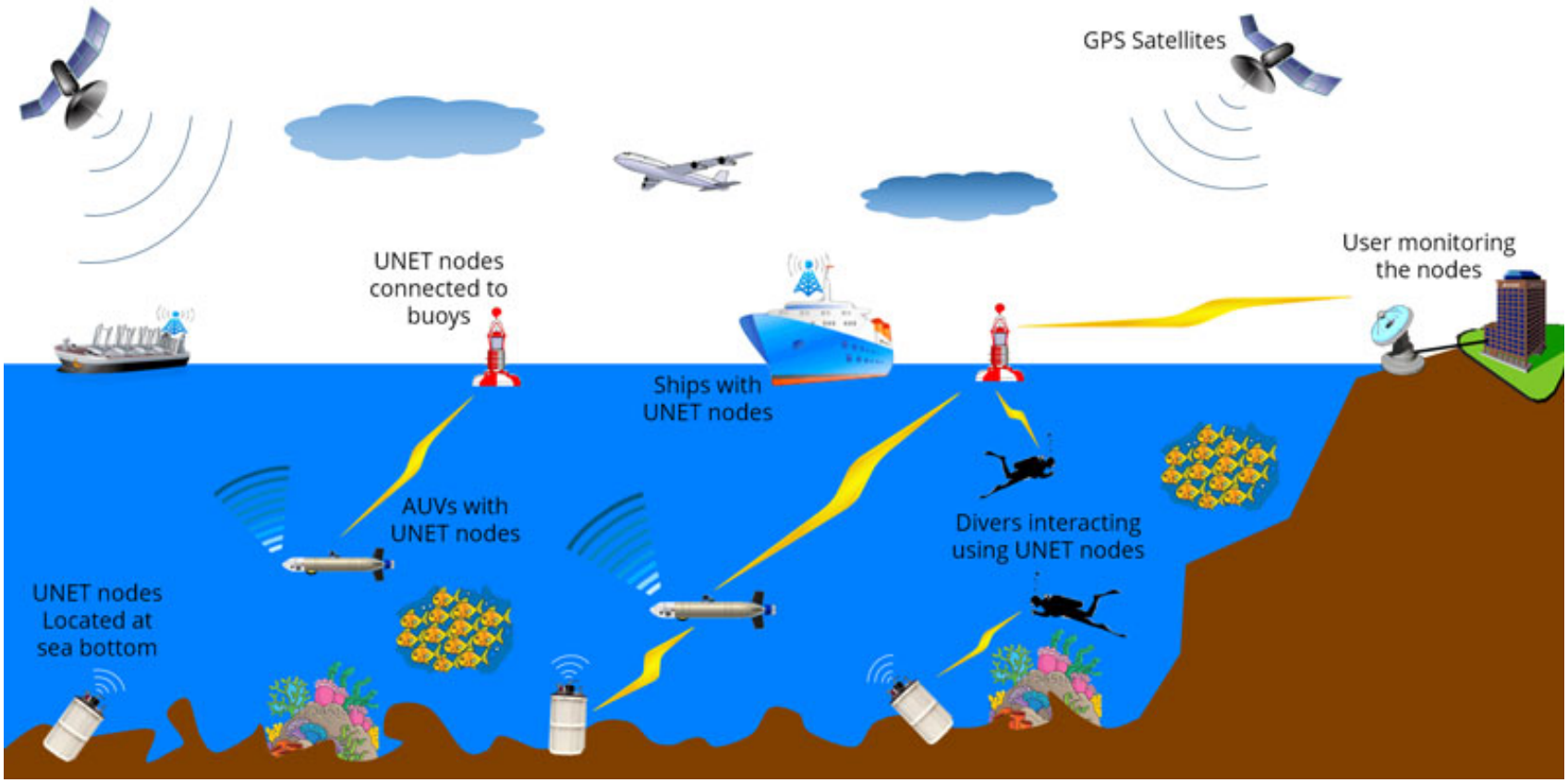
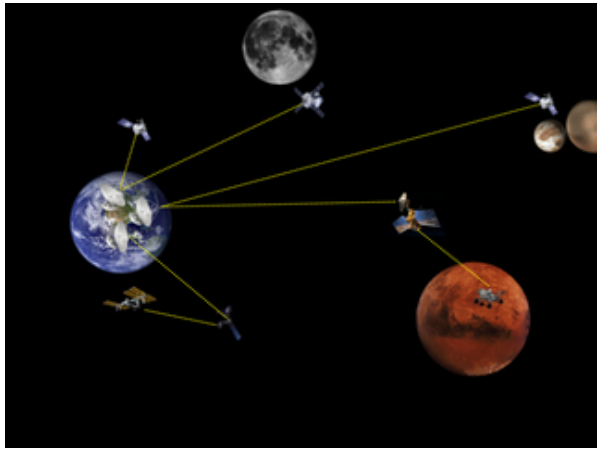
- Challenges:
  - Noise from ships, shrimp, bubbles
  - Surface characteristics
  - Interference from other transmissions
  - Link availability
  - High energy consumption
- Disruptions can be high and reliability can be low, hence an ideal place for using *DTN* protocols

Example


GPS Satellites
UNET nodes
connected to
buoys
User monitoring
the nodes
Ships with
UNET nodes
AUVs with
UNET nodes
Divers interacting
using UNET nodes
UNET nodes
Located at
sea bottom

Disruption Tolerant Networks

- Used where the communication network is likely to be disrupted due to:
  - Network Topology (Deep Space Networks / VANETs)
  - Environmental Conditions (Underwater Networks)



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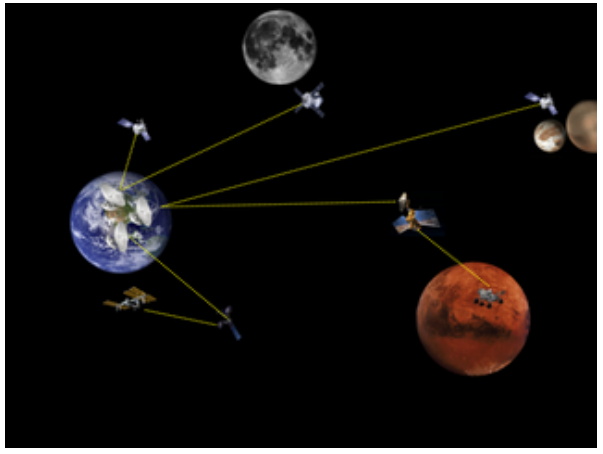

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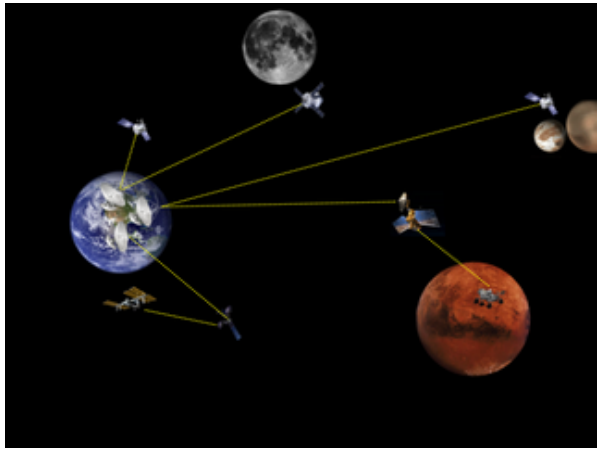
- Prioritises successful message delivery over network throughput
- Very different from typical Internet protocols!



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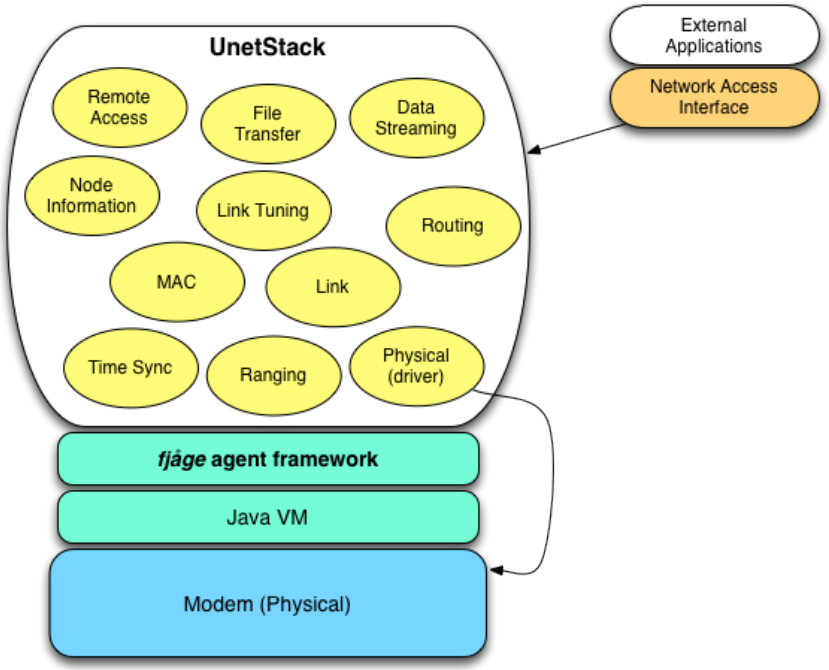
  - TTLs for messages
  - Dedicated routing algorithms (SNW, PRoPHET, MaxProp, etc)
- We are *not* going to focus on Routing and multi-copy
- Emphasis on efficiency!

UnetStack

- Underwater Network Simulator built on top of fjåge, written in Java and Groovy
- Agent based design
- Cross-layer optimisation, unlike layered network stack
- Any layer can talk to other layers!



DtnLink

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- A `LINK` agent, leveraging capabilities of existing agents

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- Let's call it `DtnLink`

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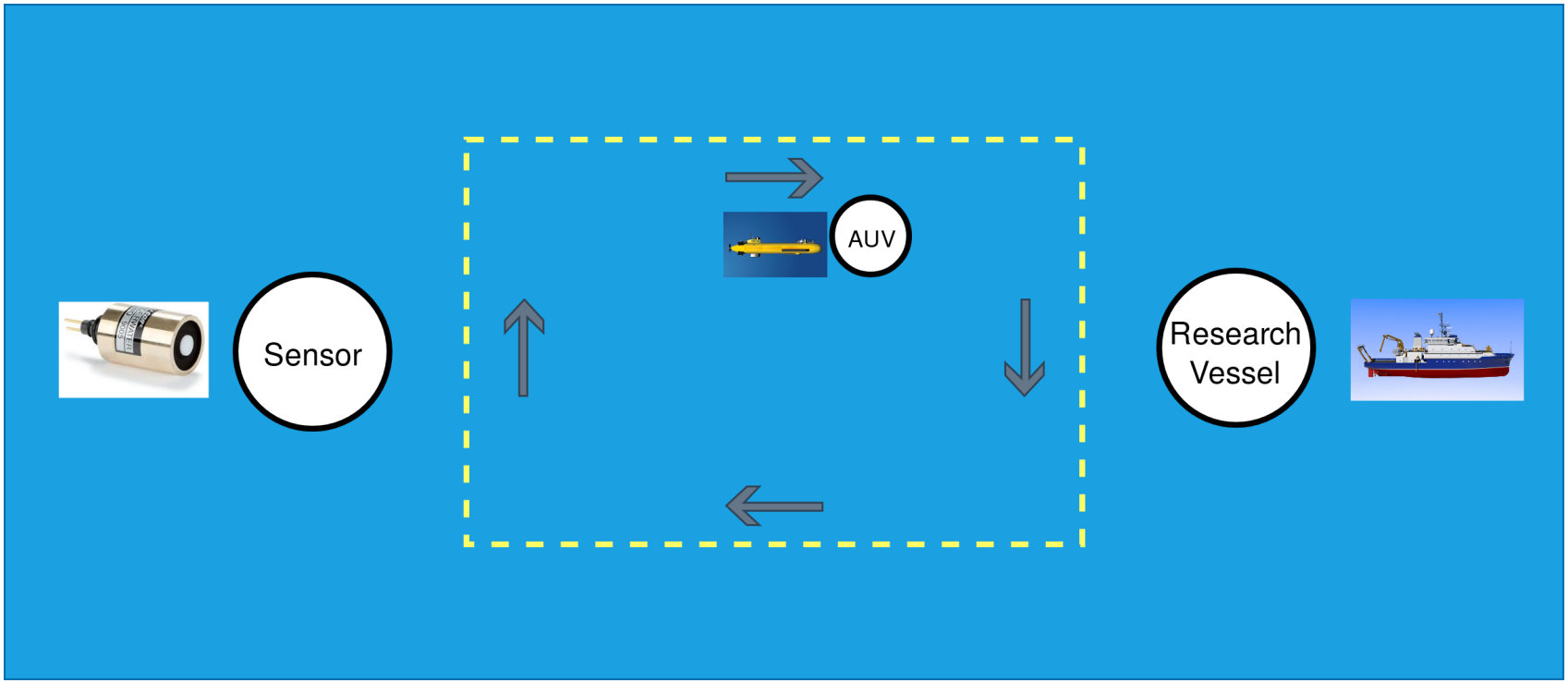
Data Muling

Using mobile nodes (e.g. AUVs) for relaying messages



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  - Time Varying Links

Time Varying Links

- In underwater networks, not all links may be available at all time
  - Acoustic links
  - Optical links
  - WiFi/LTE links
- How do we choose the link to use?

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- `DtnLink` can choose the link based on which it `SNOOP`s a message
- Each node periodically sends *Beacons* for advertisement

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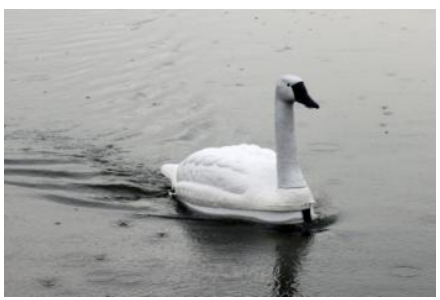

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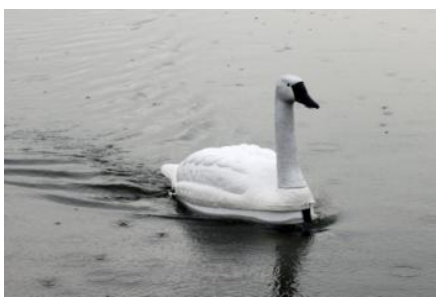

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- Some ideas:
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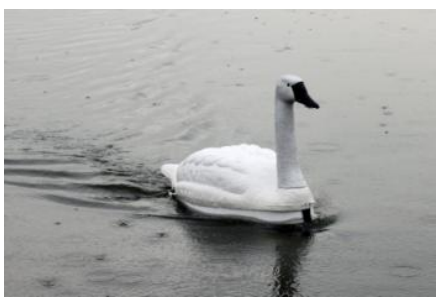
- *...and many more*



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- Features
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  - Detection of duplicate messages
  - Stop-And-Wait sending
  - Support for multiple links
- Configurable Options
  - Link Priorities
  - Order of sending messages (`ARRIVAL`, `EXPIRY`, `RANDOM`)
  - Short-circuiting (send messages to destination without DTN headers)

PDU Structure

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- Consists of Headers + Data
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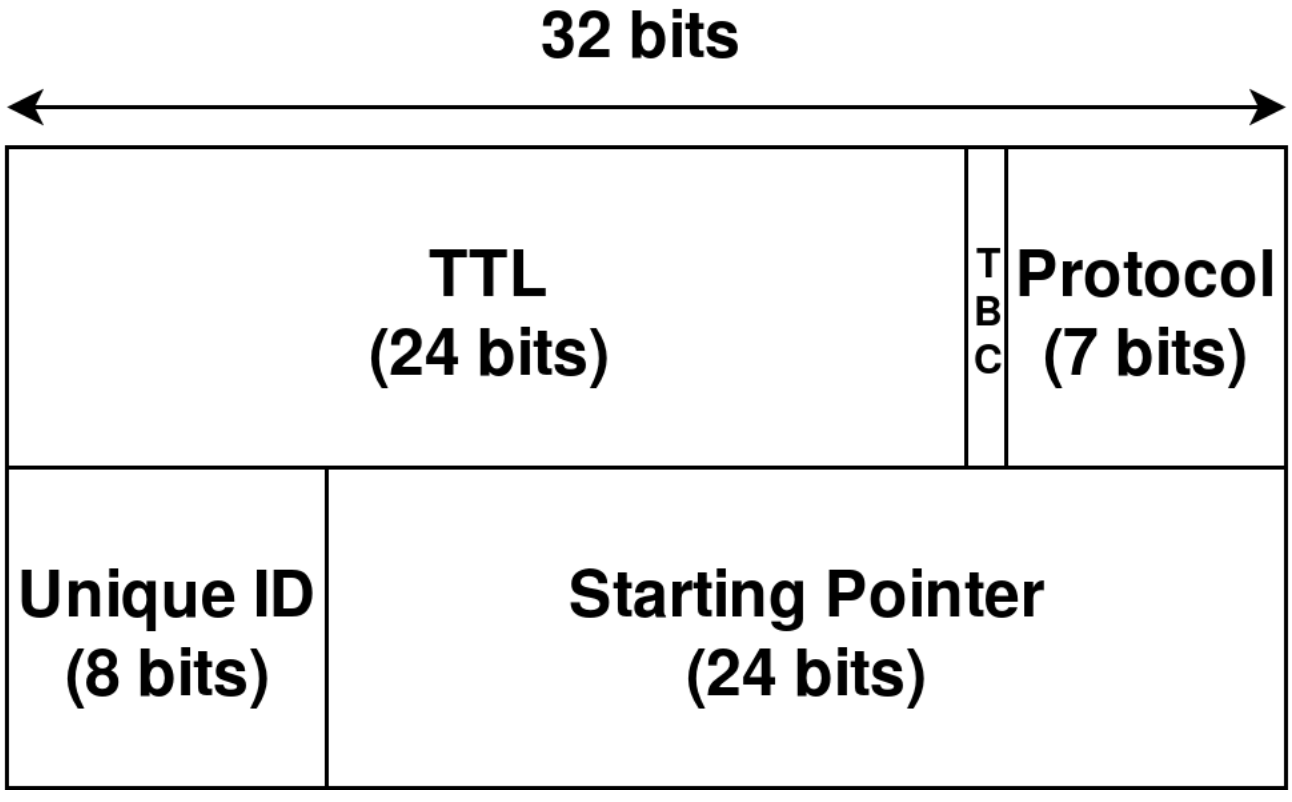
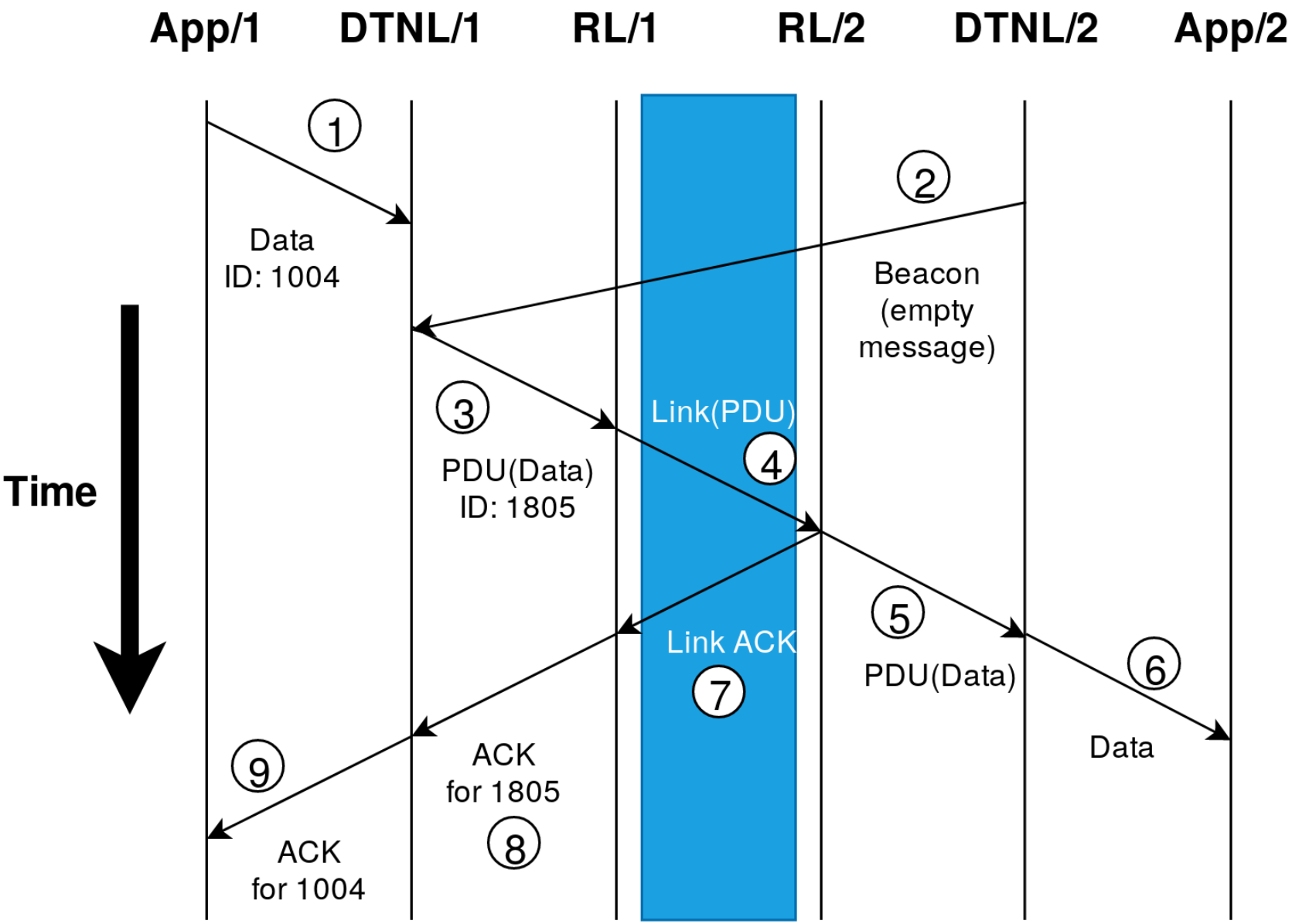
- Added before the first byte of the data
- `DtnLink` uses a 64 bit header
- PDU size *must* be less than the MTU[1] of the Link used

[1] MTU = Maximum Transmission Unit

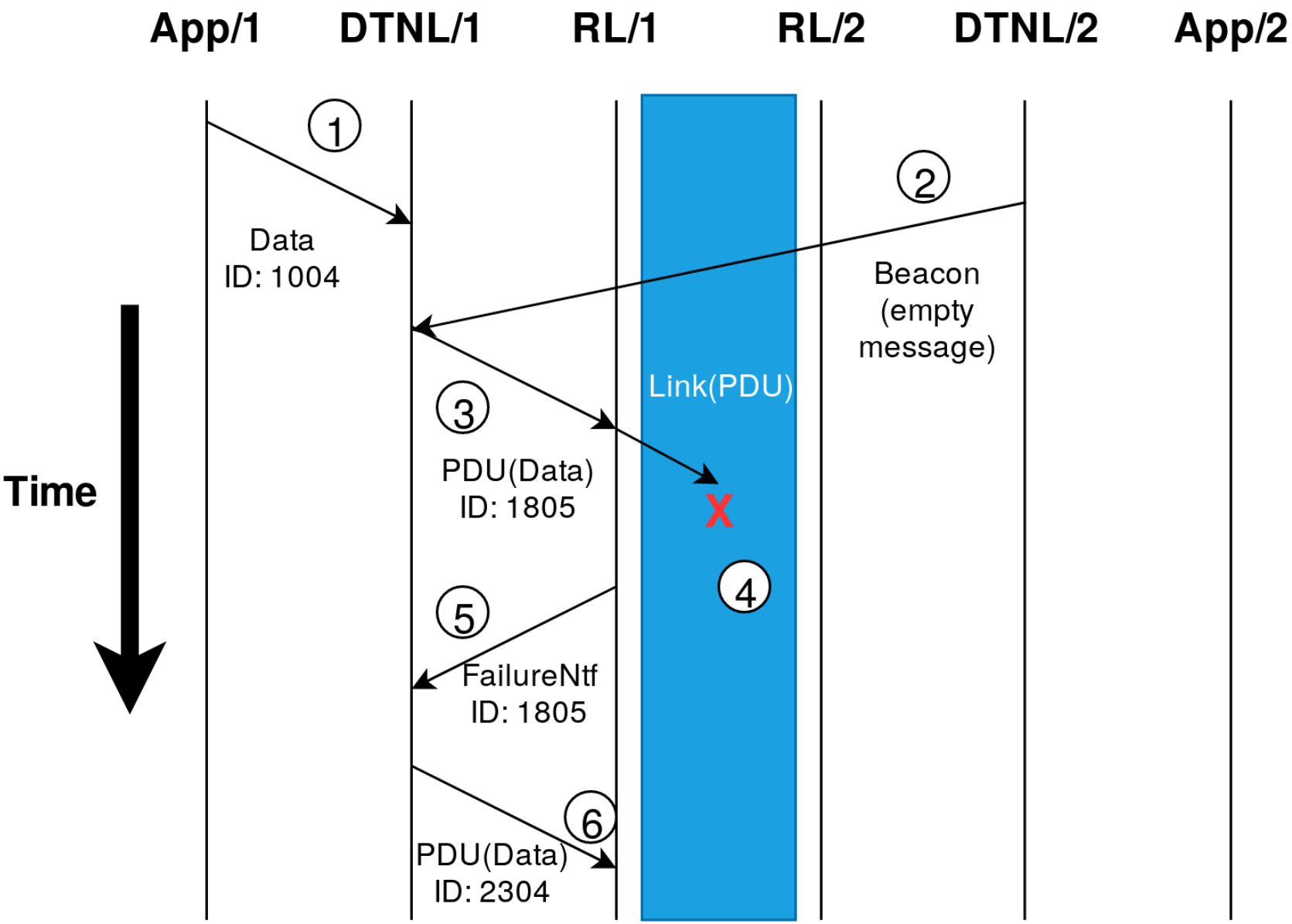
PDU Structure



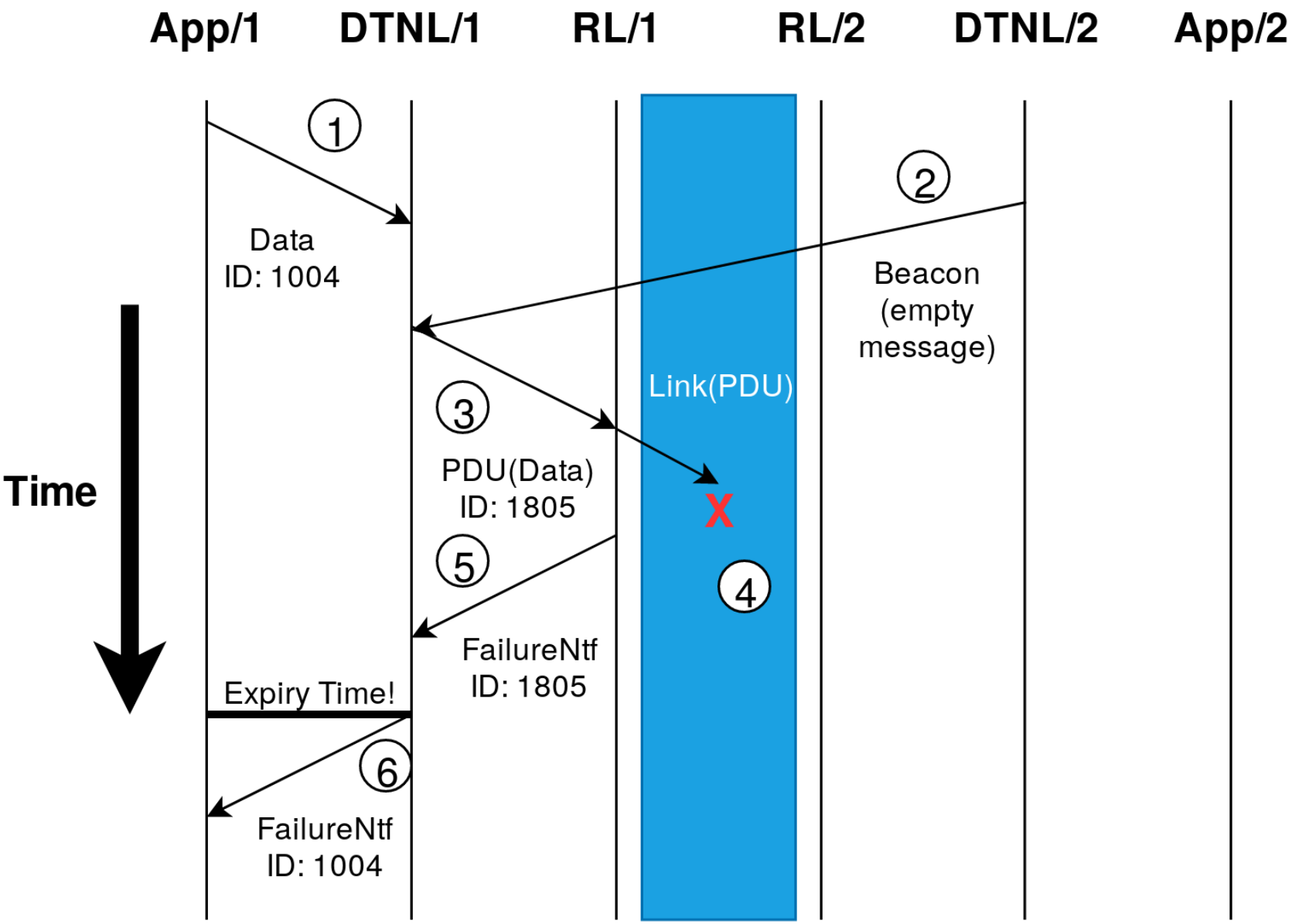
Successful Delivery



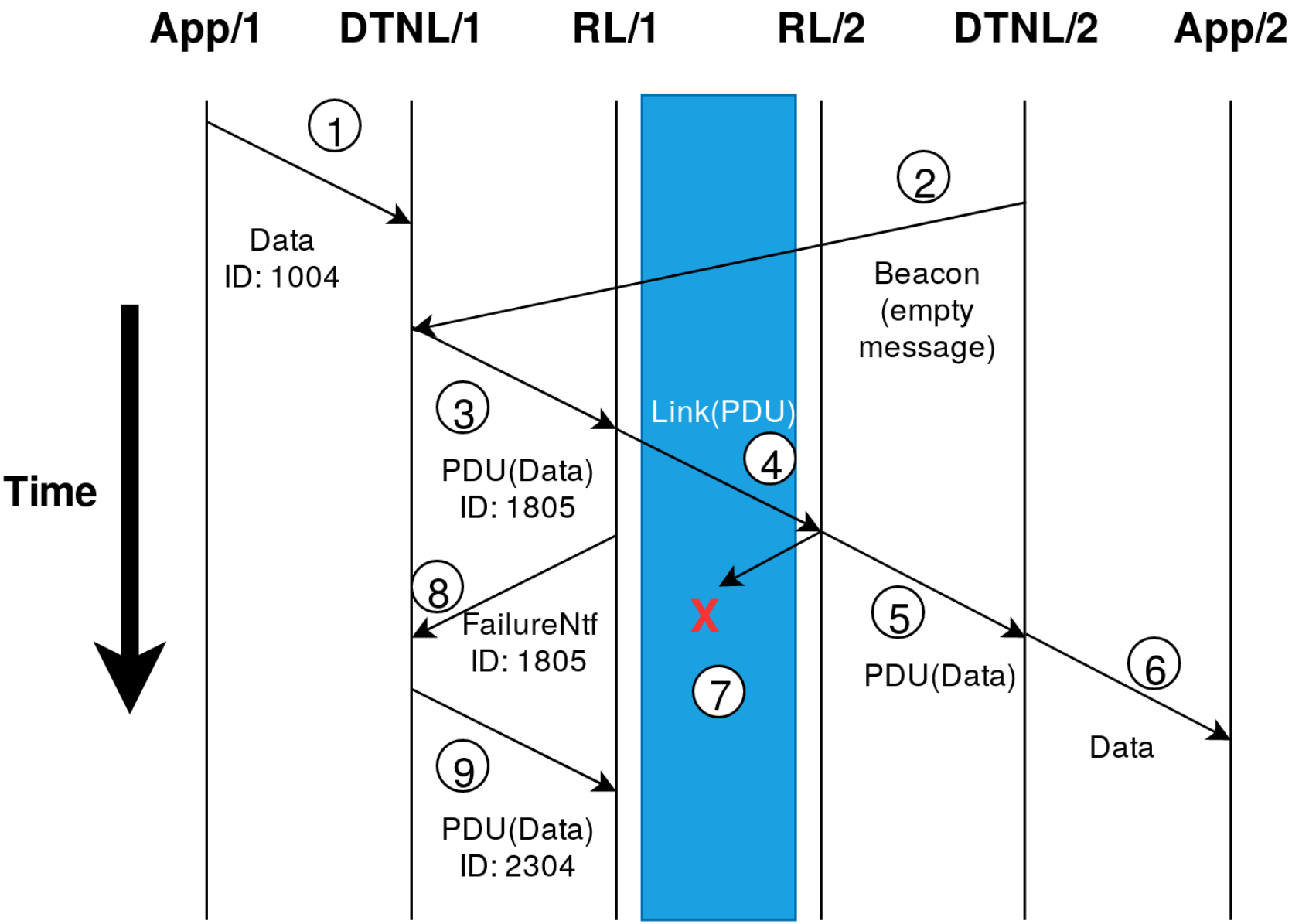
Delivery Failure



TTL Expiry


App/1
DTNL/1
RL/1
RL/2
DTNL/2
App/2
1
Data
ID: 1004
2
Beacon
(empty
message)
Link(PDU)
3
PDU(Data)
ID: 1805
X
4
5
FailureNtf
ID: 1805
Time
Expiry Time!
6
FailureNtf
ID: 1004

ACK Failure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PDU(Data)
6
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Duplicate Messages

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- We need a way to identify duplicate messages

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- We need a way to identify duplicate messages
- Idea: use a nonce for each message

Detecting Duplicate Messages with Hashing

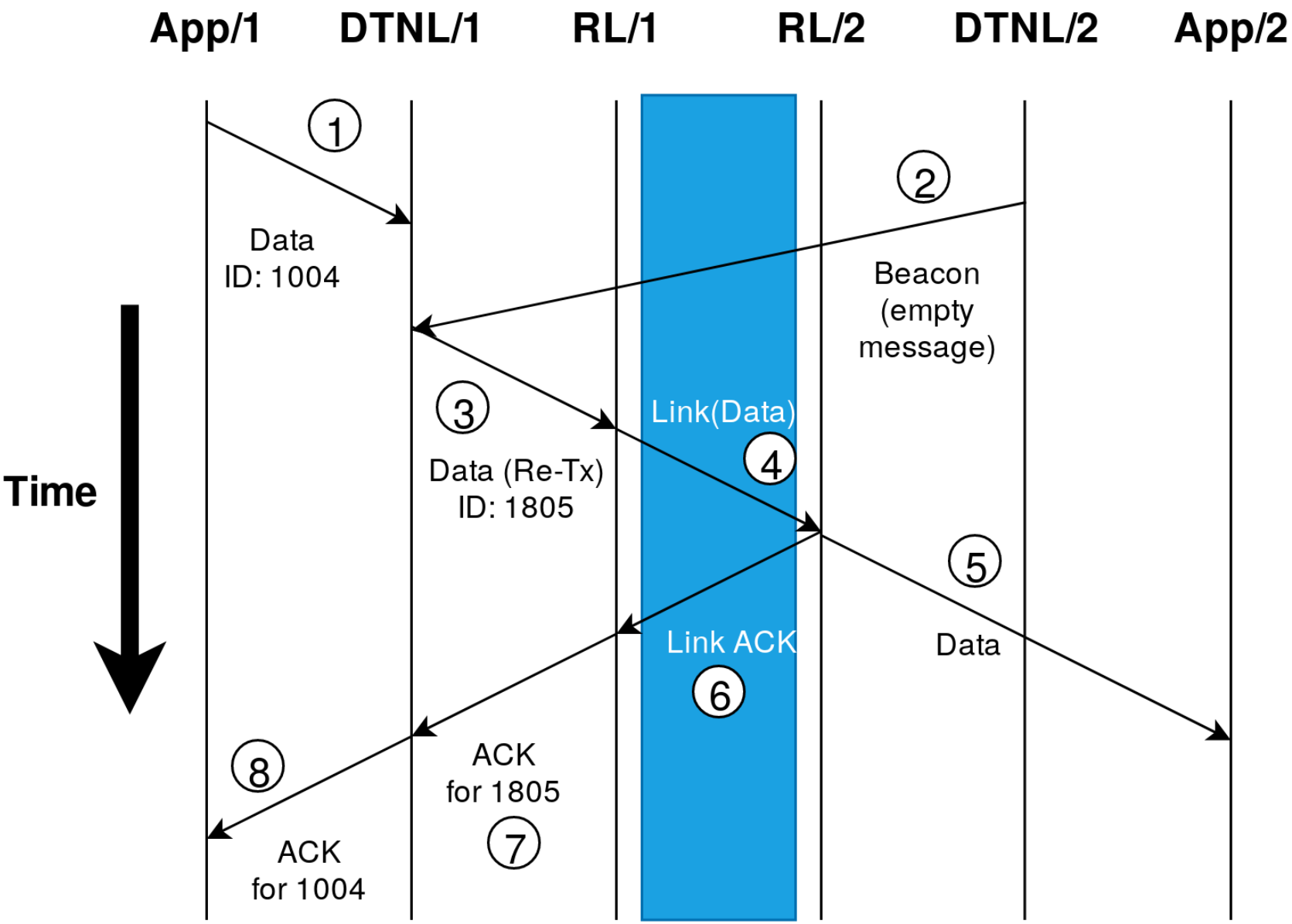
Sender

- Sender encodes a nonce in the PDU for each message

Receiver

- Receiver computes `hashCode` of message data and the nonce
- Stores this value in a `Set`
- If current message's `hashCode` exists in the `Set`, discard the message
- Otherwise, send it up to the application

Short circuit



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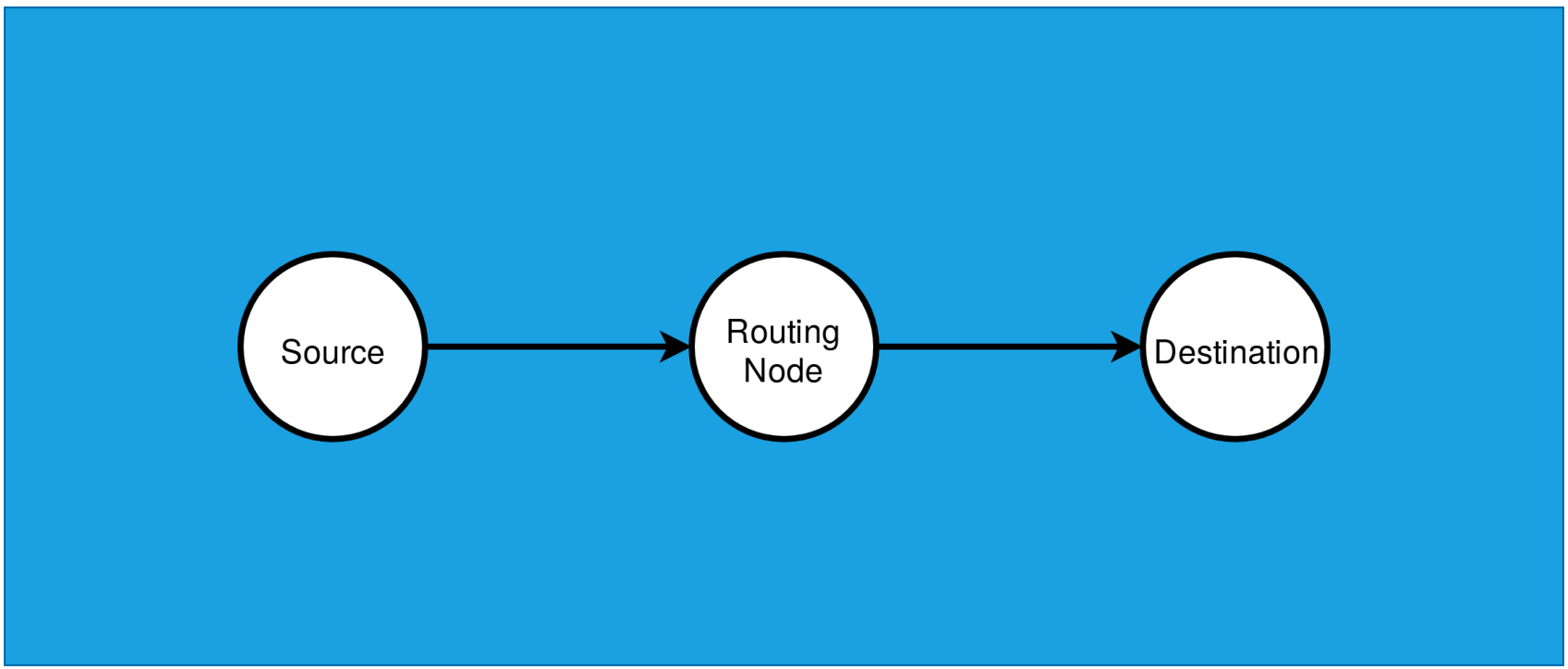
Multihop simulation



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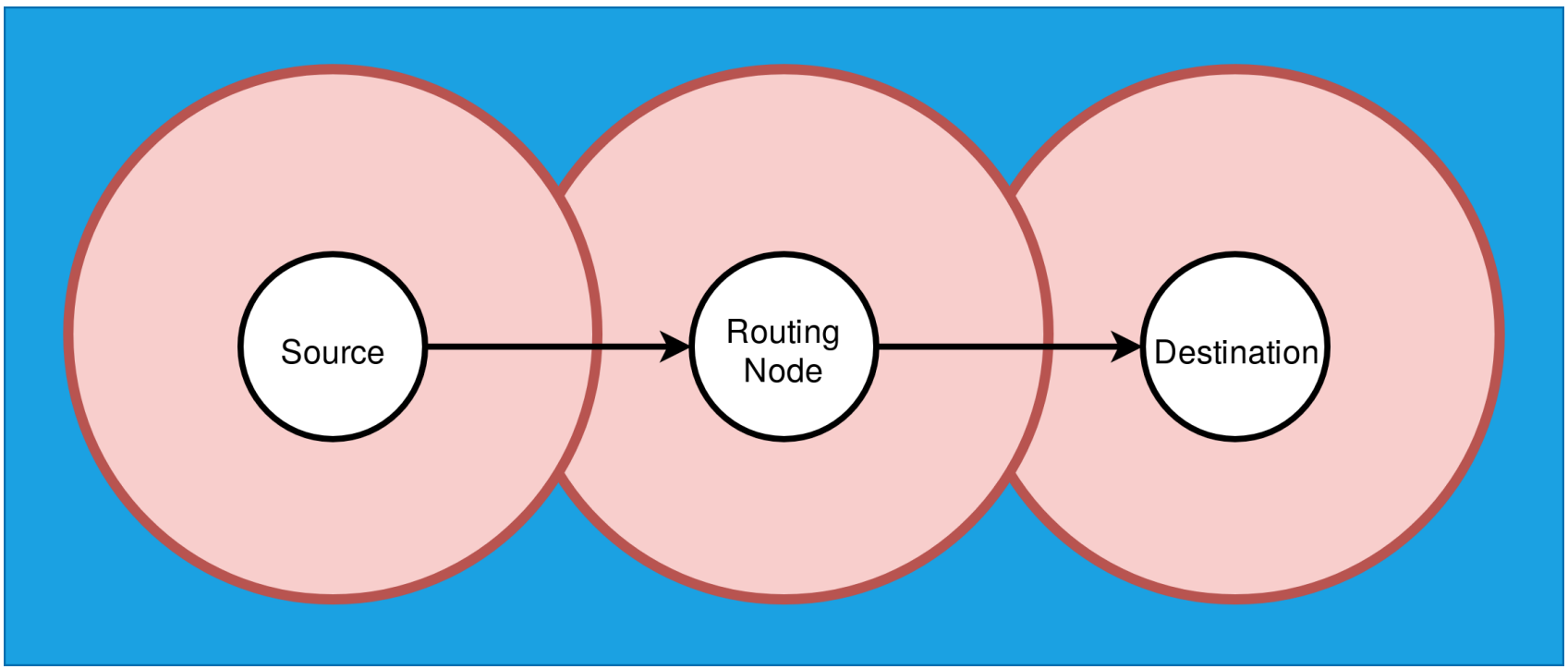
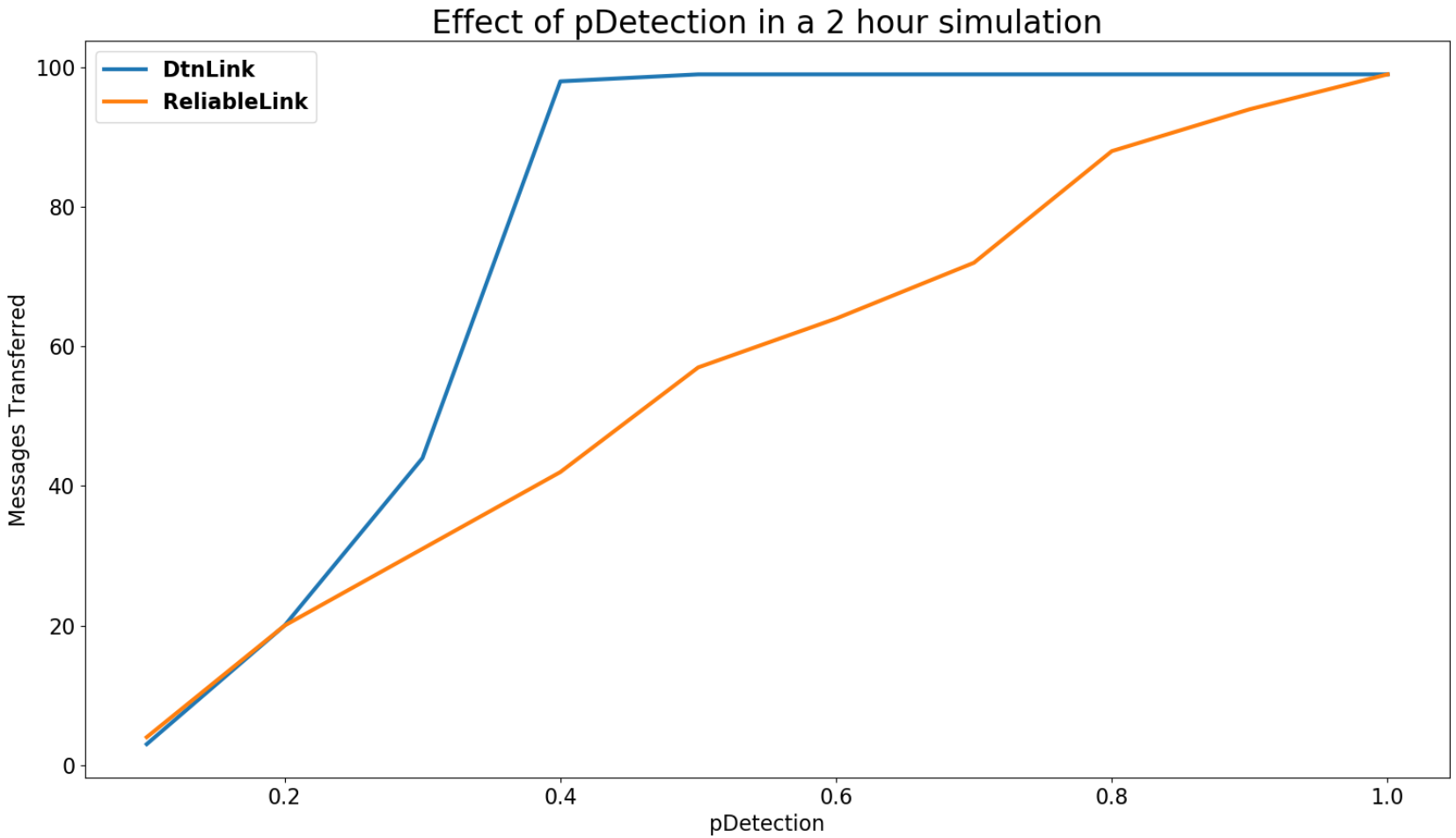
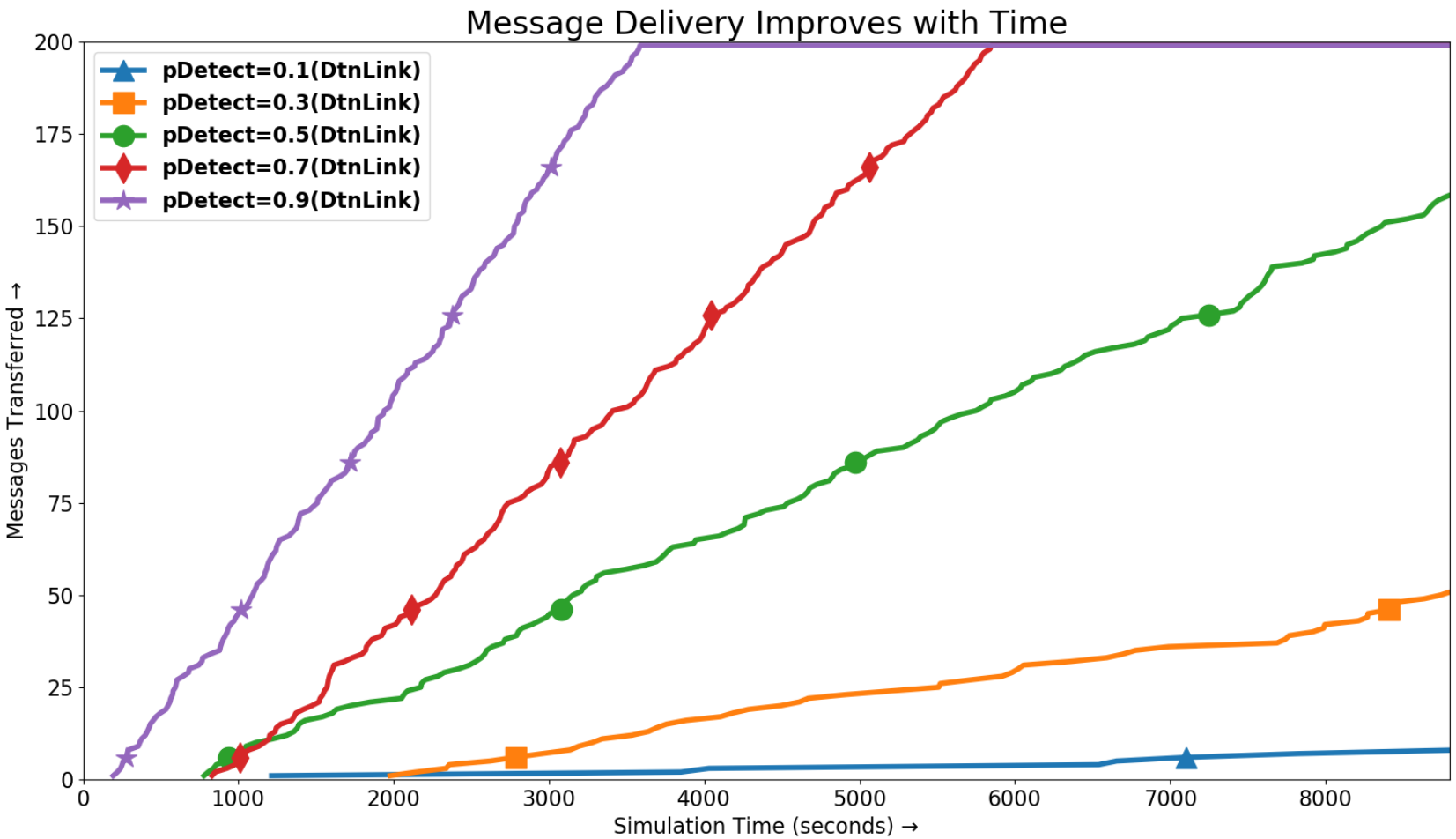


DtnLink versus ReliableLink



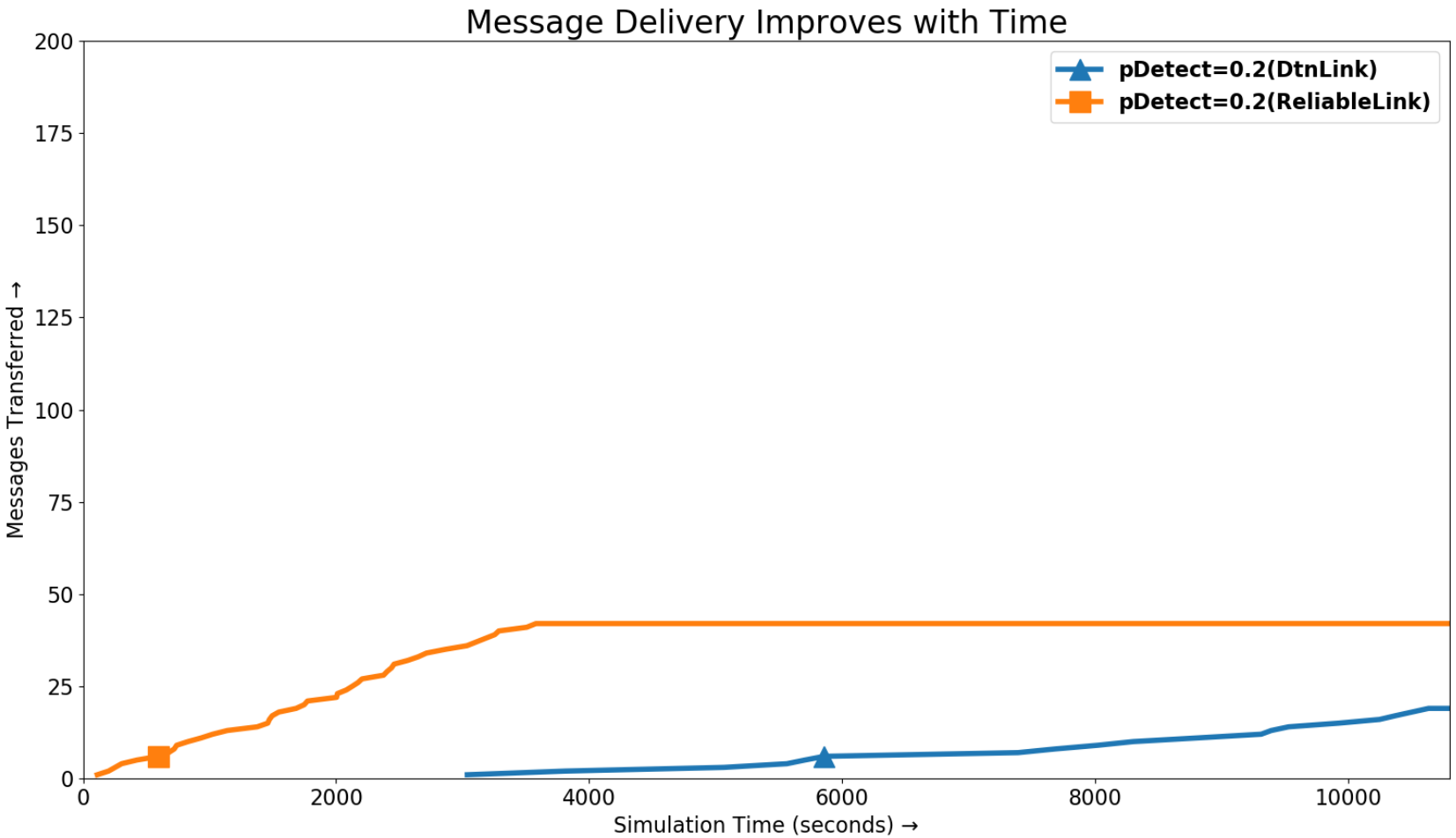
Message delivery keeps improving with time!



However...

`DtnLink` is not a panacea!

ReliableLink versus DtnLink, varying pDetection



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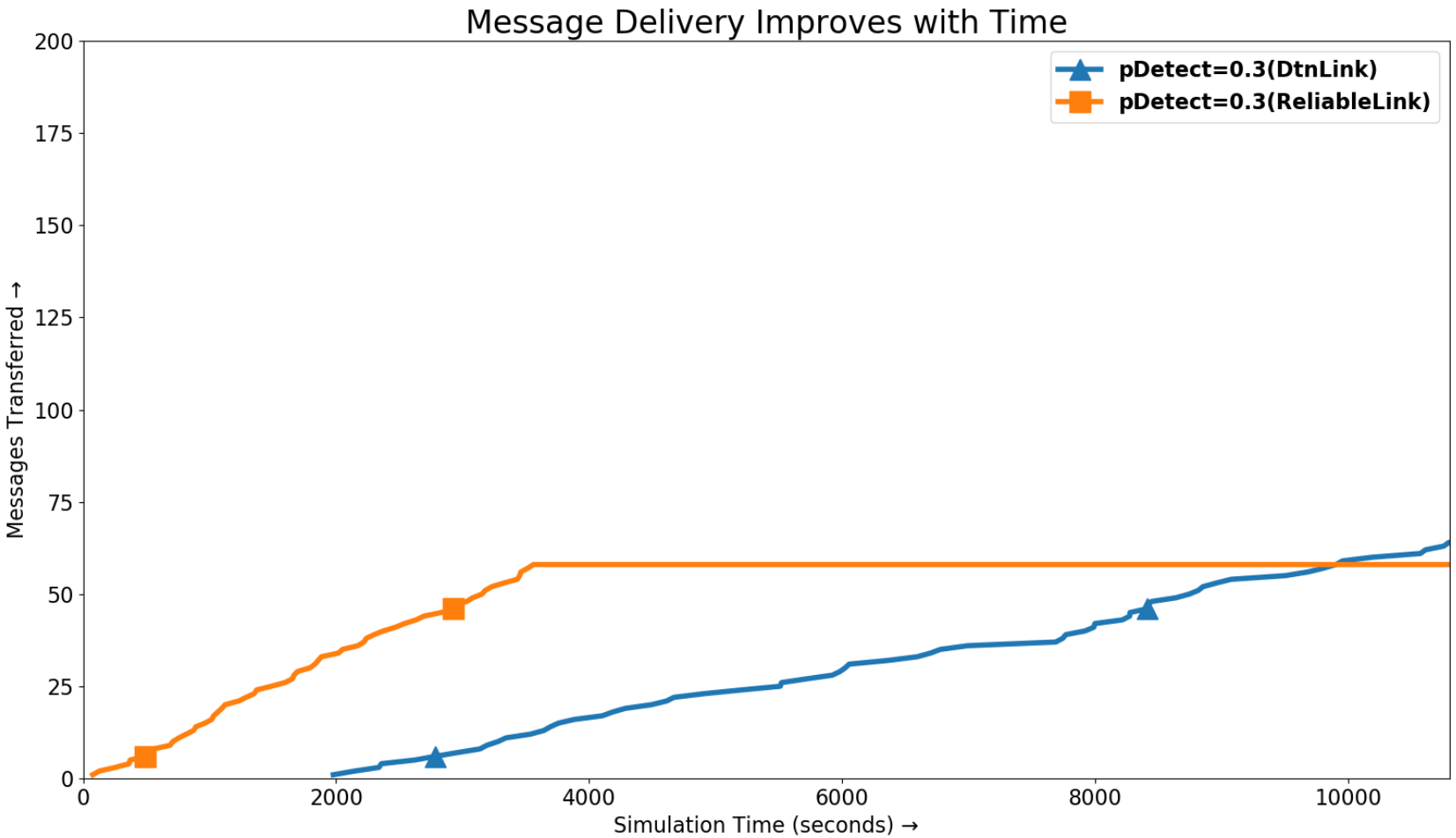

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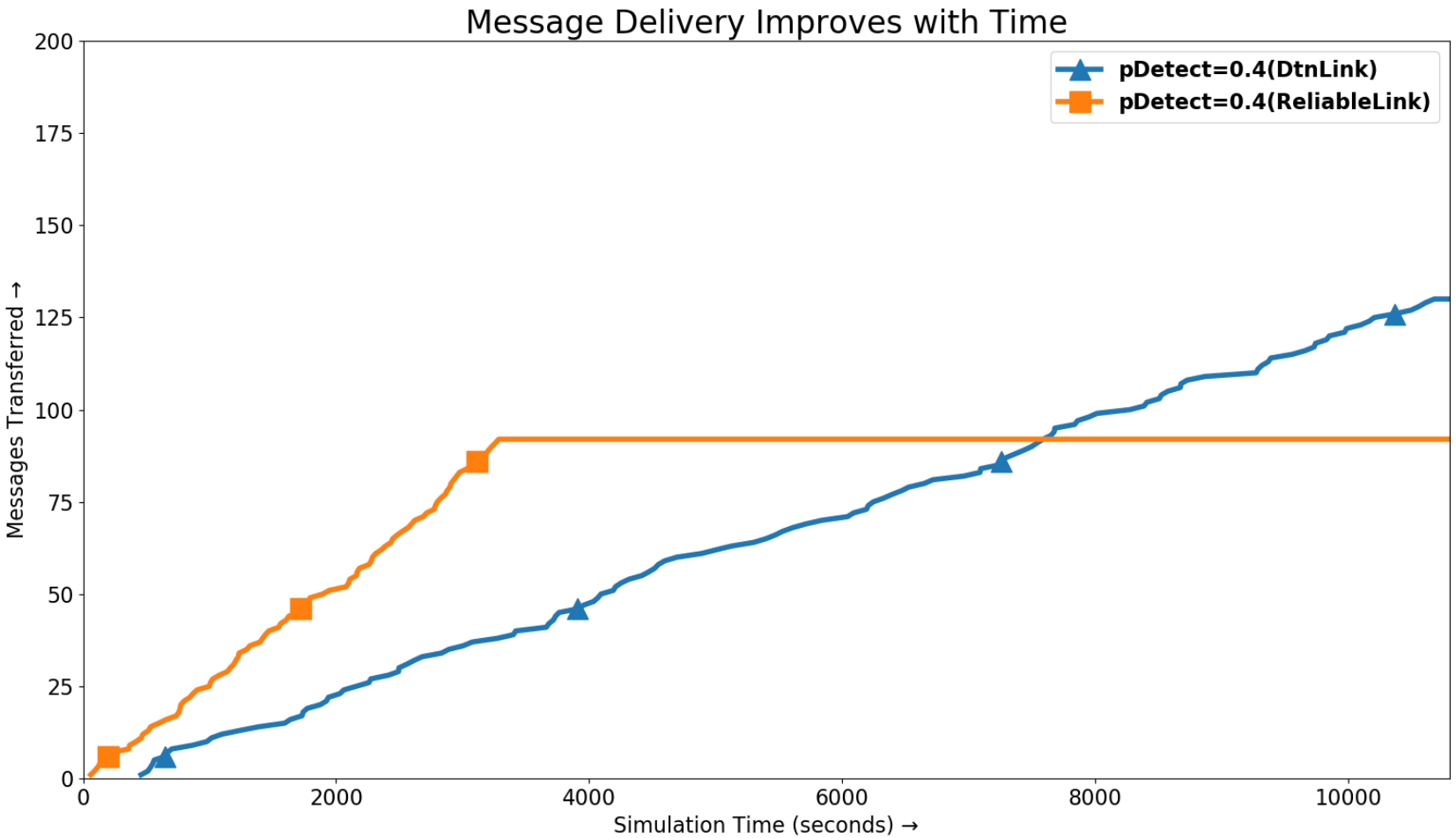

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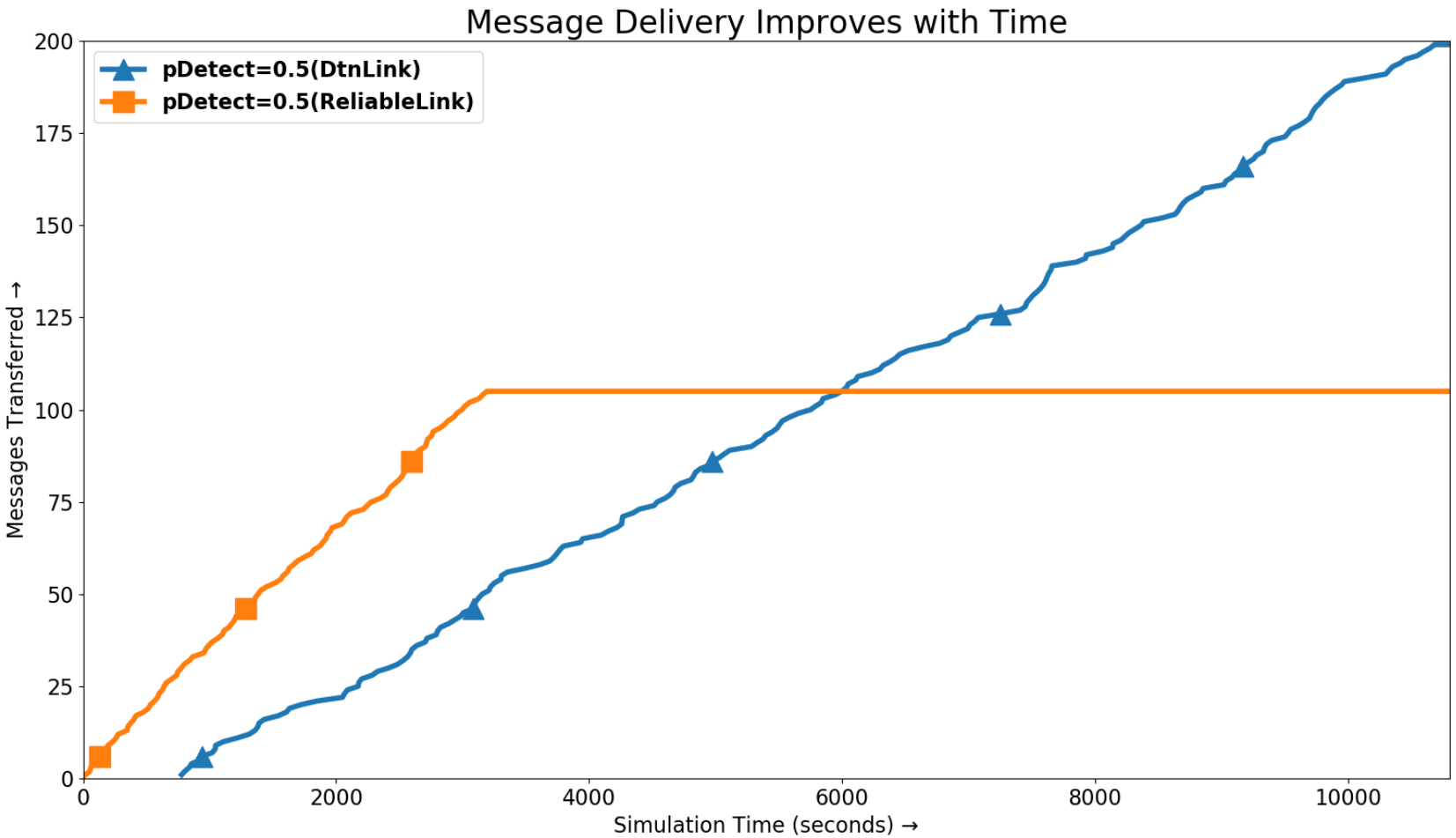

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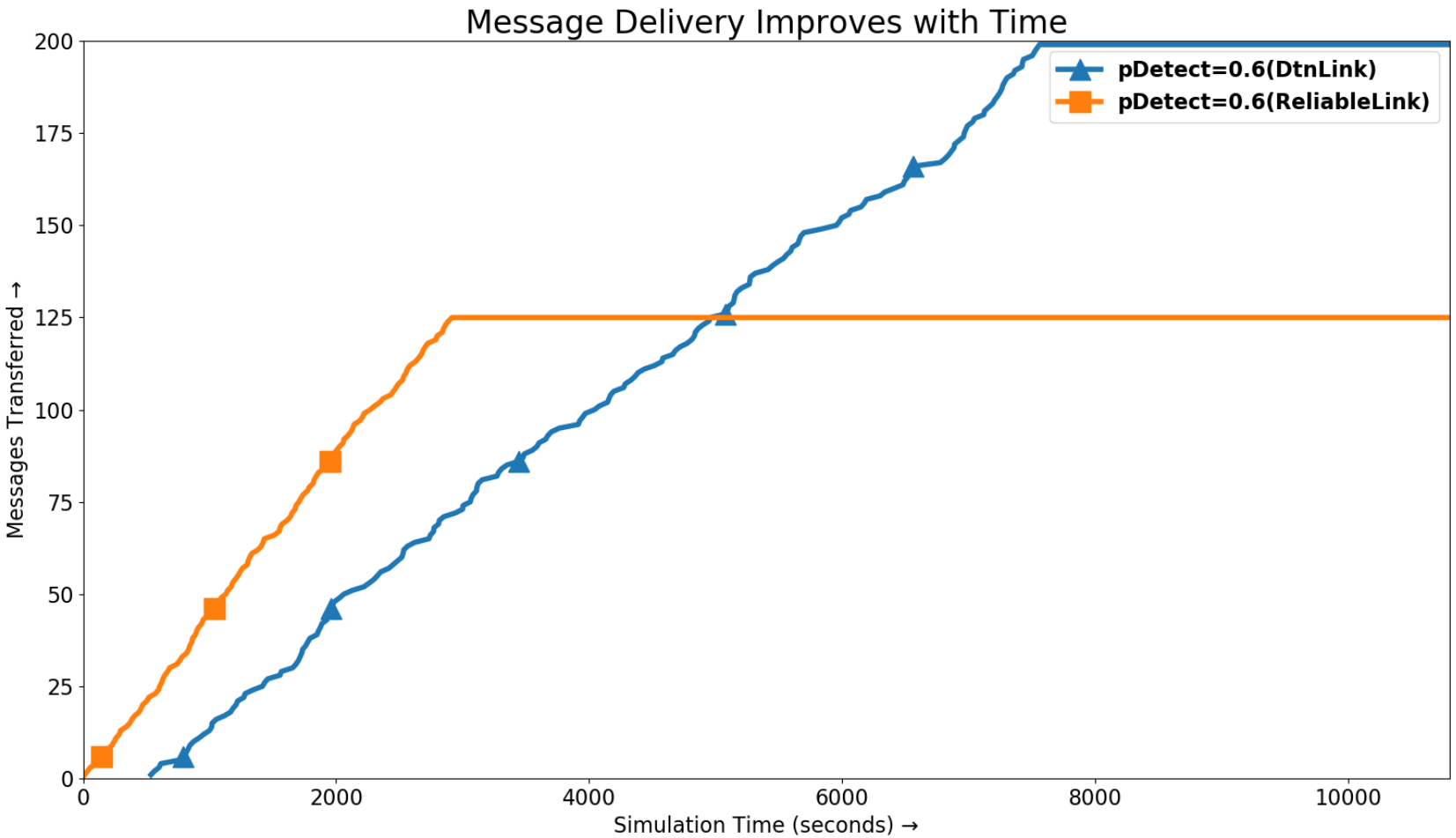

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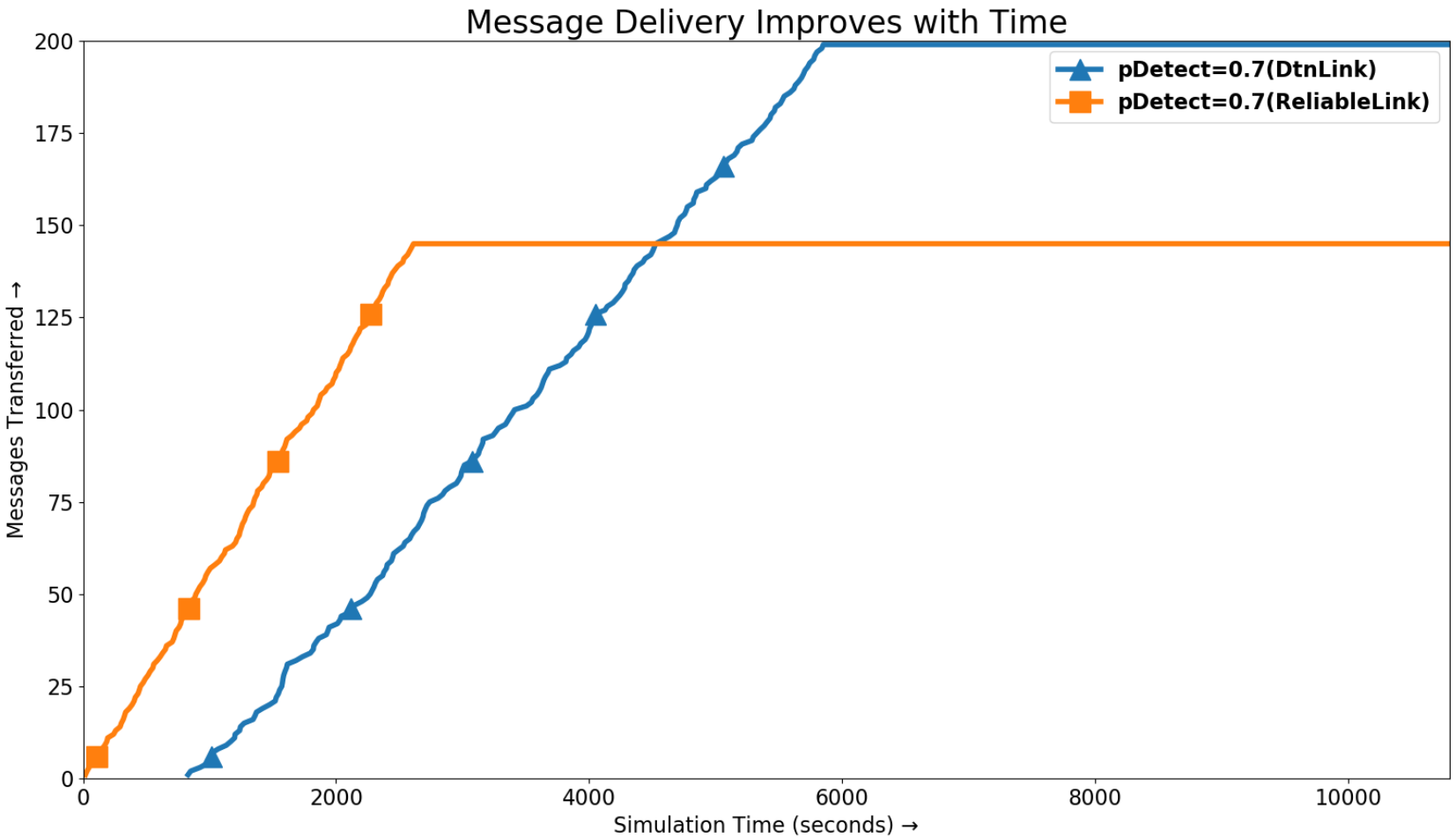

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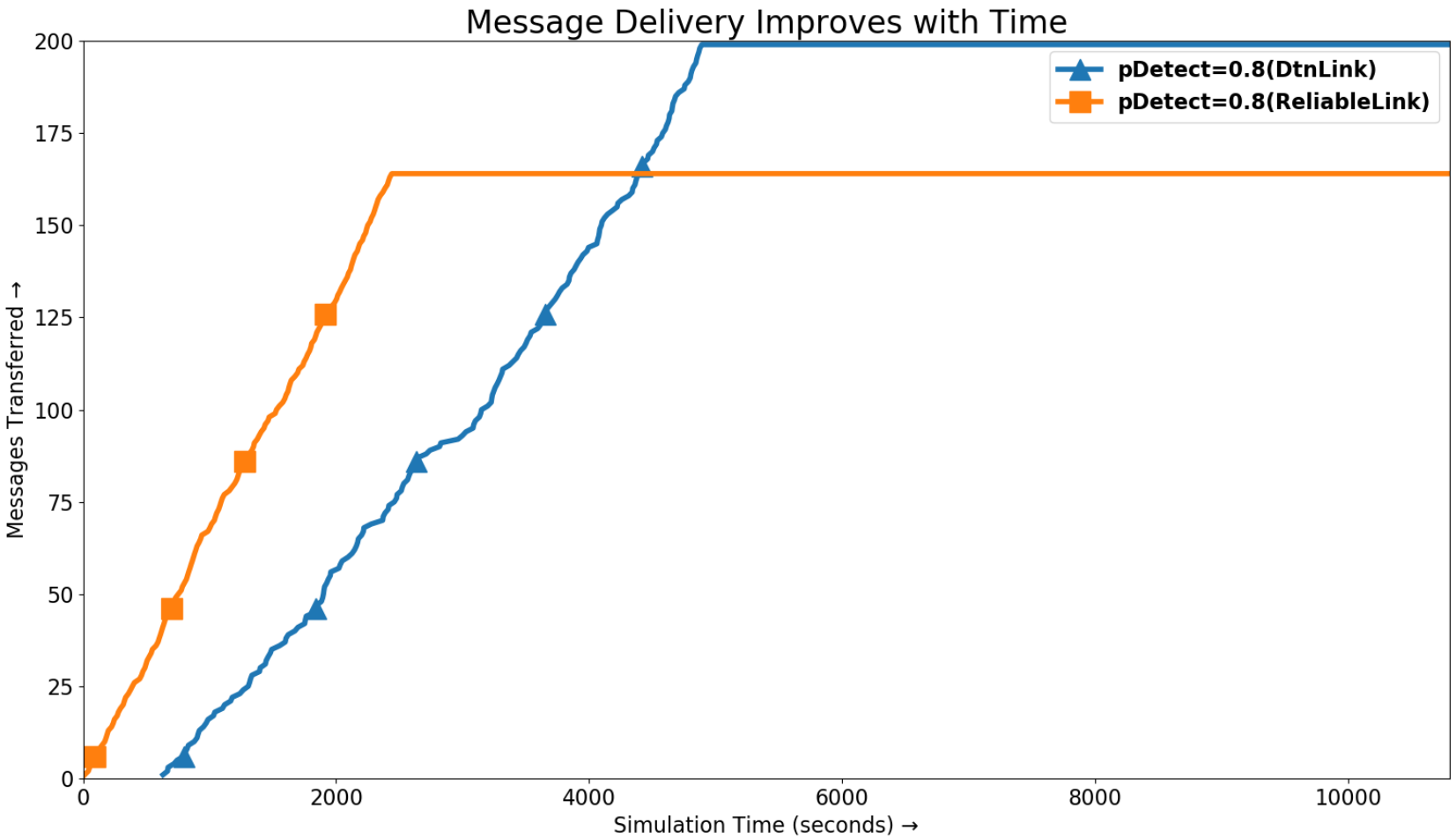

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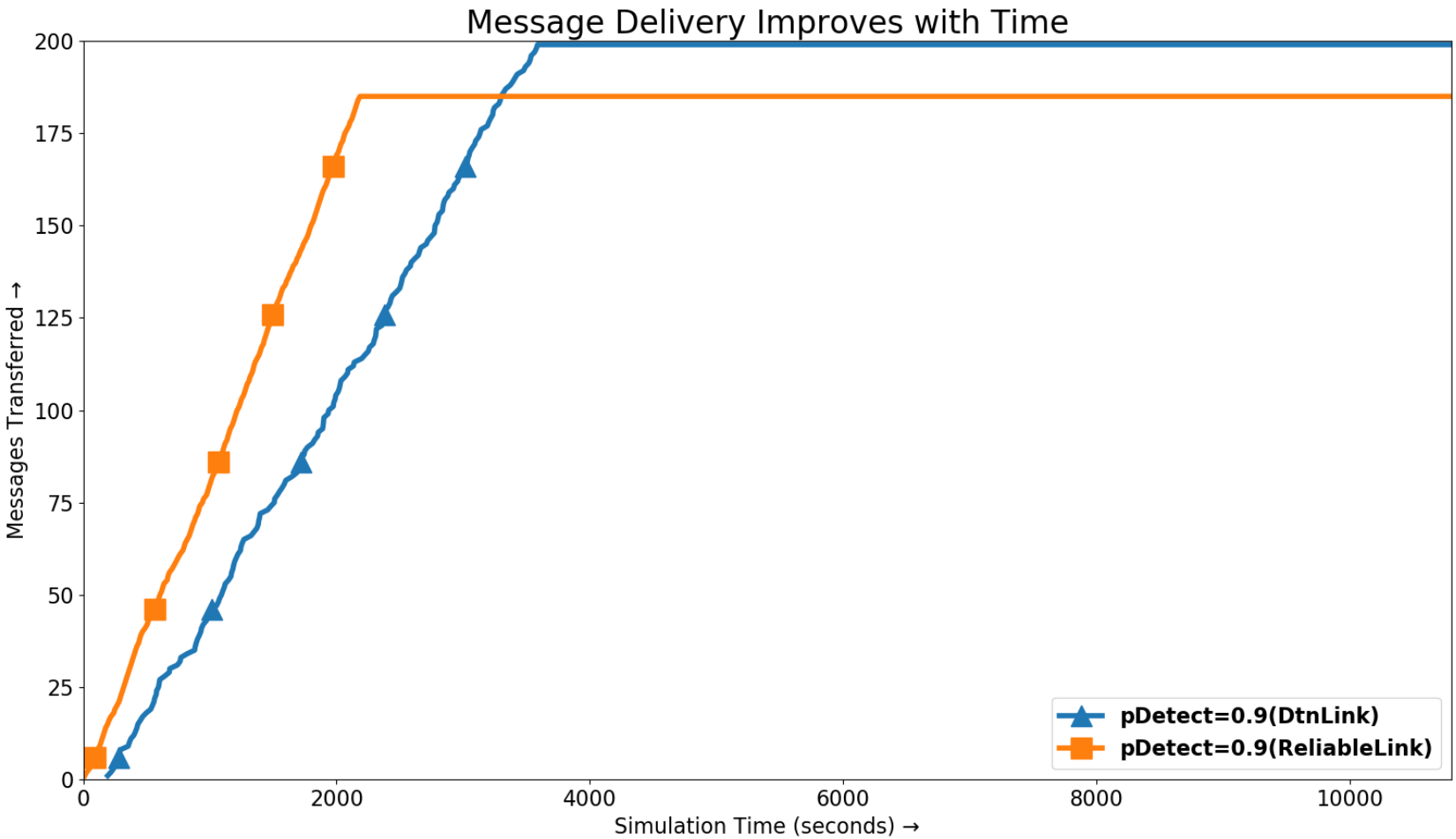
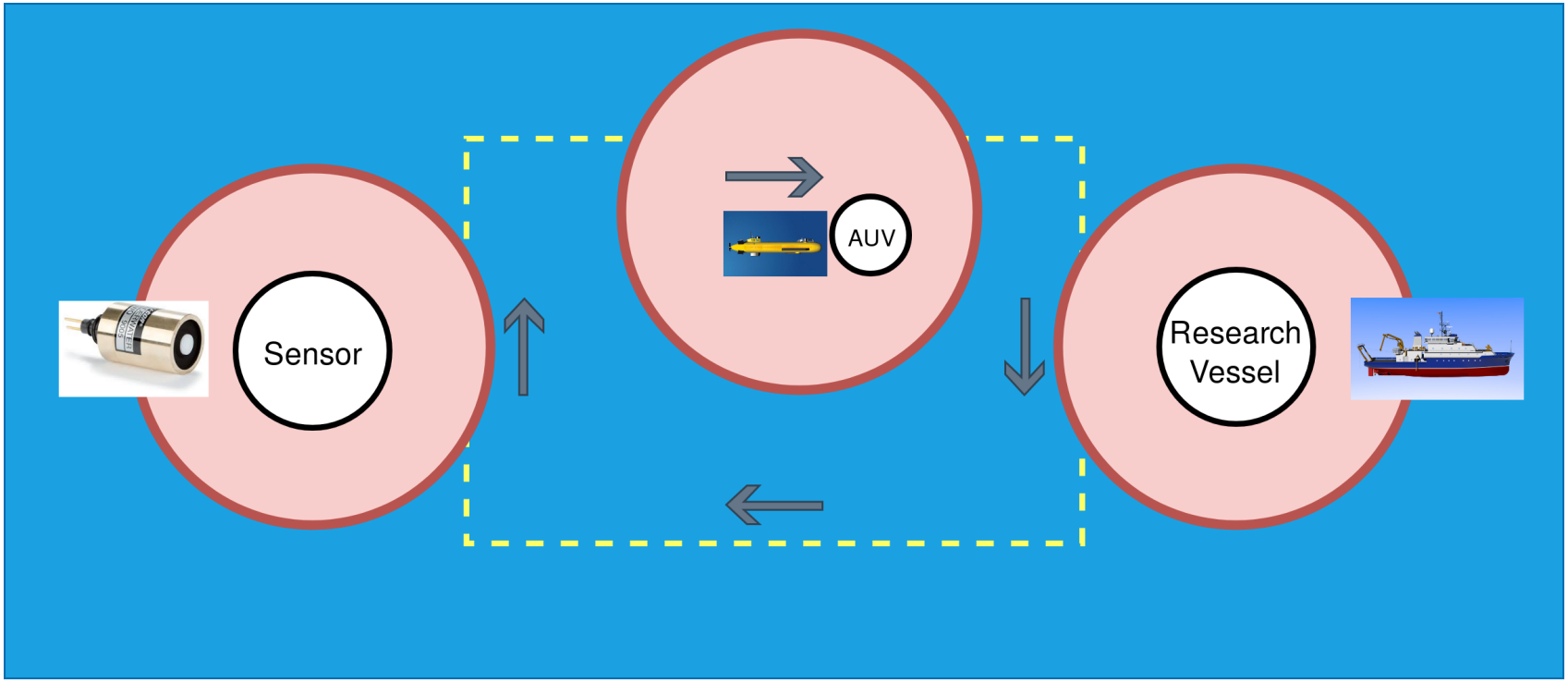
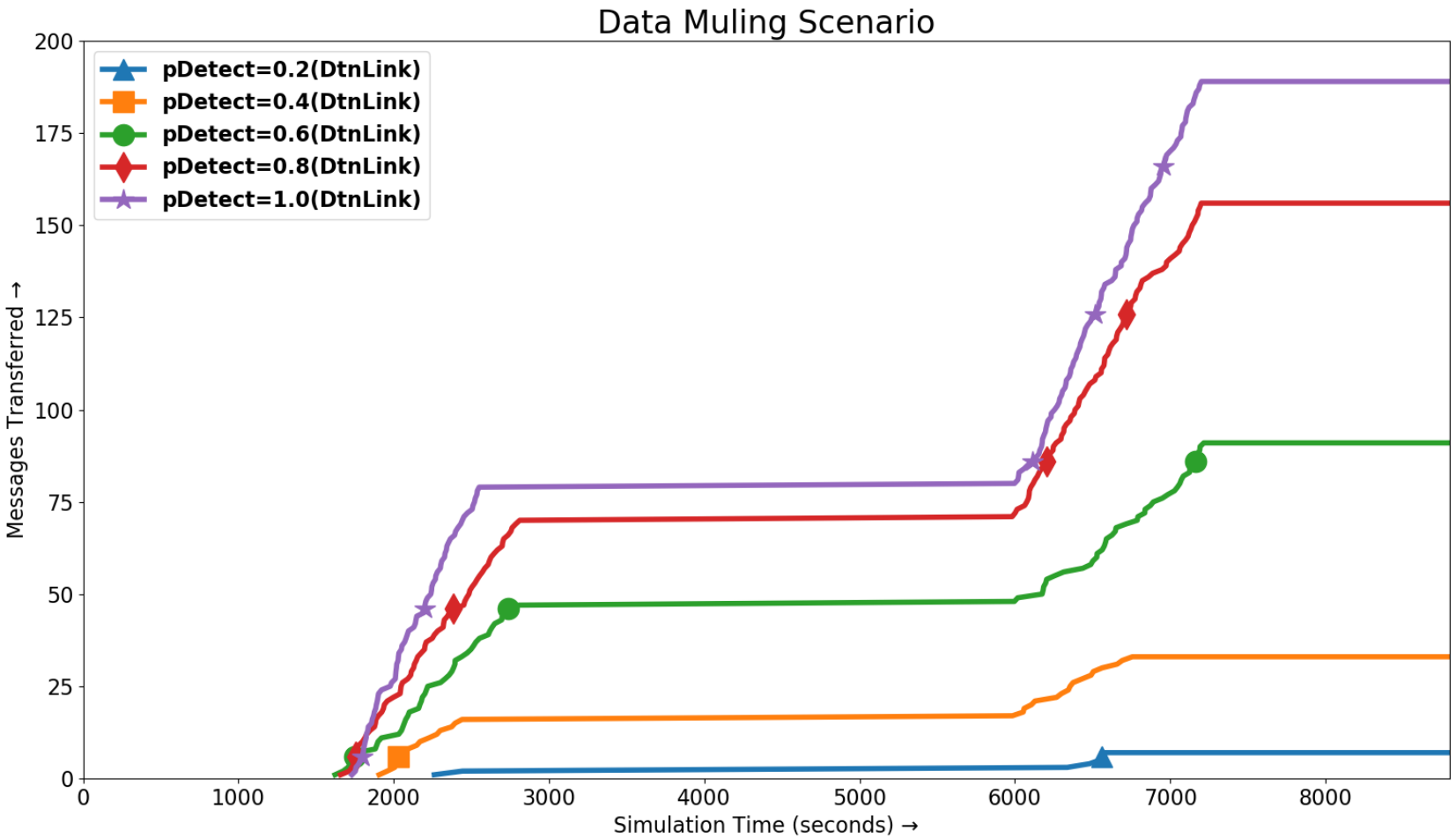


Data Muling Simulation



Data Muling Results



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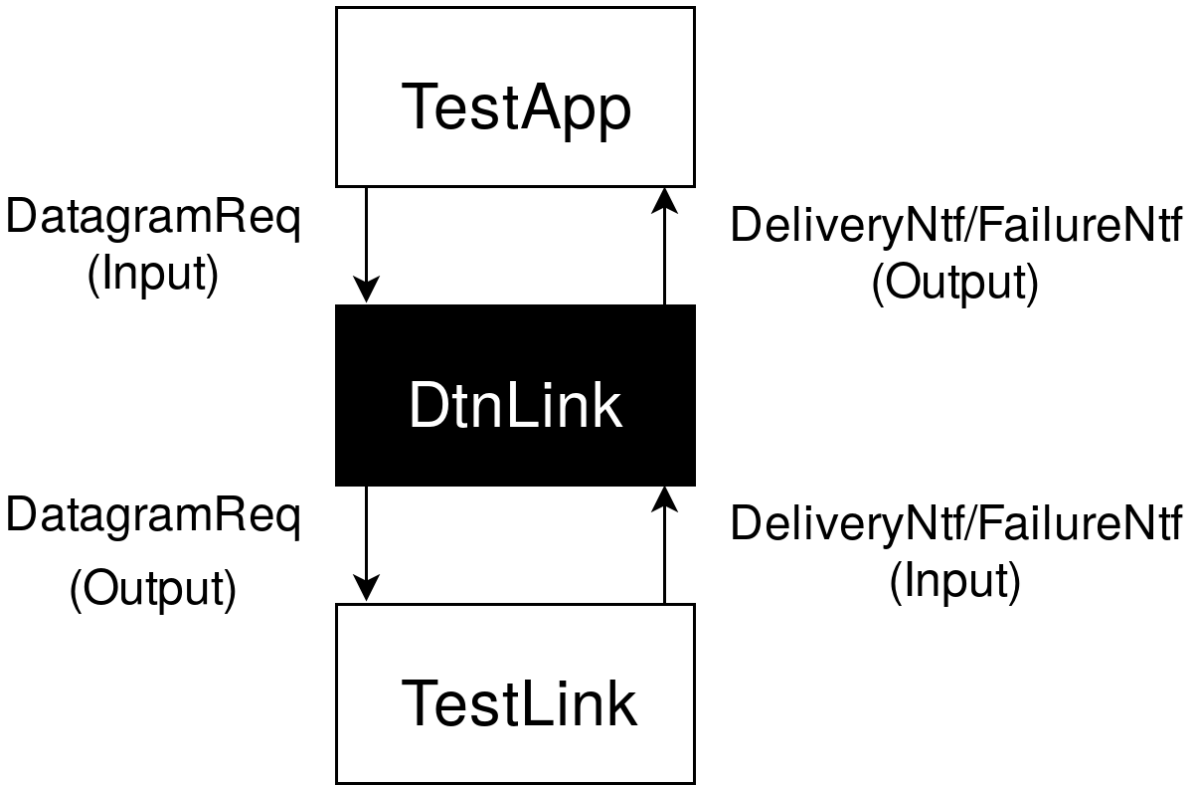
- Unit testing can help us by *automatically* testing crucial functionality of `DtnLink`
- *Regression testing* is checking for if anything breaks between changes

Black Box Testing

DtnLink Test Harness



Tests Conducted

- TRIVIAL_MESSAGE
- SUCCESSFUL_DELIVERY
- ROUTER_MESSAGE
- BAD_MESSAGE
- EXPIRY_PRIORITY
- ARRIVAL_PRIORITY
- RANDOM_PRIORITY
- LINK_TIMEOUT
- MULTI_LINK
- PAYLOAD_MESSAGE
- REBOOT

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Future Work

- `DtnLink` has some limitations which can be addressed in the future:
  - Stop-And-Wait is slow
  - TTL of messages doesn't include propagation delay
  - Multi-copy routing
  - End-to-end acknowledgements for multihop will need transport level control - `DtnTransport`

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  - Useful in data muling and switching between different links
- Stop-And-Wait sending reduces collisions but this can make it slower than `ReliableLink` in some situations
- Simulations help us understand the use cases better

Thank you!