Bulk Data Transfers through an Airline Delay-Tolerant Network

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Problem Description

- Vast amount of digital information is produced with a rate that grows exponentially
- Many of them are non-real time data
- Although, research centers and universities have to exchange vast amount over the world for several reasons.


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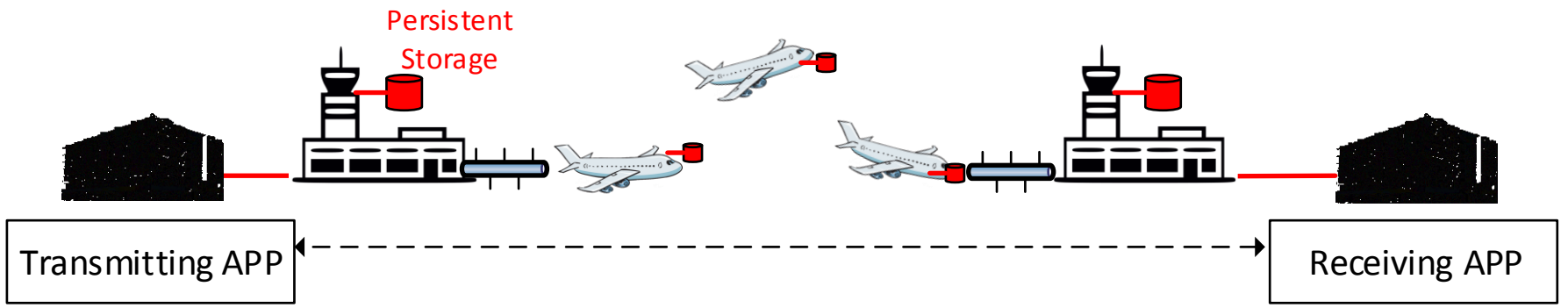
NATS

System Architecture

- Fiber optics links
- High-capacity network drives
- High capacity Ethernet
- Storage Disks (e.g. Solid-State Drives)



Delay/Disruption Tolerant Networking (DTN) Architecture

- Intermittent connectivity
  - no end-to-end path
  - connection and disconnection between nodes depends on flight schedule
- Long delay
  - long interarrival time between flights
- Forwarding data through Store and Forward method
  - the data is stored in high-capacity network drives in airport
  - the data is stored in storage disks on airplane

Contact Graph Routing (CGR) Algorithm

- This algorithm works by using a contact plan
- {FromNode ID, ToNode ID, Contact Start Time, Contact End Time, Transmission rate, Propagation delay}
- The data is segregated into multiple bundles
- For each bundle, the algorithm calculate the earliest path to destination
- The routing procedure is executed in every node through the path to destination
  - each node recalculates the optimal route towards to the data destination

Evaluation methodology

- **European Space Agency's (ESA) internal dedicated network**

European Space Agency's (ESA) internal dedicated network

The European Space Agency's internal dedicated network interconnects ESA's assets inside Europe.

The internal network has high-speed connections (1, 2.5 and 10 Gbps), in order to transfer a vast amount of space data among them.

Evaluation methodology

- European Space Agency's (ESA) internal dedicated network
- **DTN Simulator**

Evaluation methodology

- European Space Agency’s (ESA) internal dedicated network
- DTN Simulator
- **FlightStats Web Services API**

Contact Plan in our System

- Contacts between research centers and airports
  - Continuous contacts
  - Transmission rate equals to the optical fiber speed
- Contacts between airport storage and airplane storage
  - Intermittent contacts with contact intervals of one hour
    - **prior to the flight time** in source
    - **after to the flight arrival** at destination
  - Transmission rate equals to the
    - storage **writing** speed in source
    - storage **reading** speed at destination
- The contacts that represent the flights
  - propagation delay equal to the flight time

Evaluation methodology

- European Space Agency's (ESA) internal dedicated network
- DTN Simulator
- FlightStats Web Services API
- **Simulation parameters**

Parameter	*Value*
Bandwidth of optical fiber	10Gbps
SSD read speed	500Mbps
SSD write speed	377Mbps
Number of ssd	60
Bundle size	10GB

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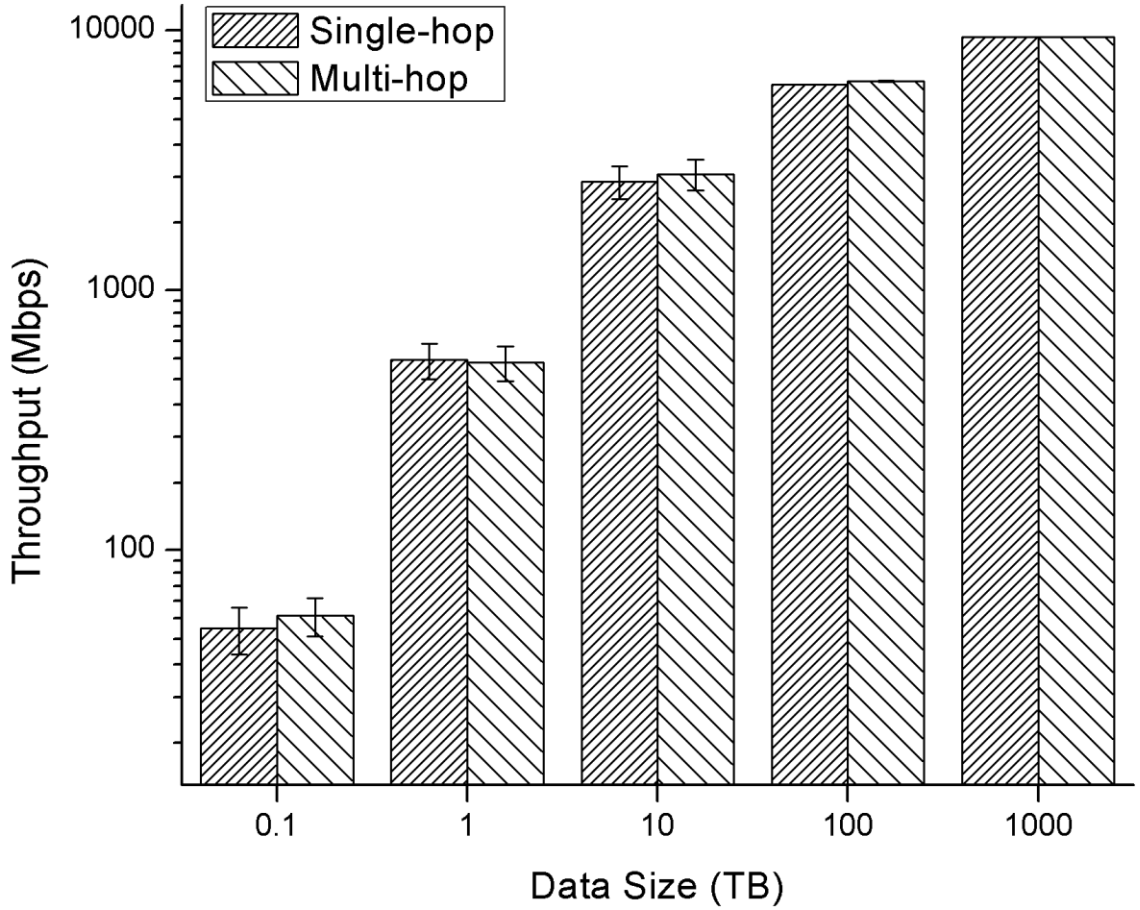
- **For each scenario we conducted 30 simulations with different transmission start time**

Throughput for one-to-one over different data sizes



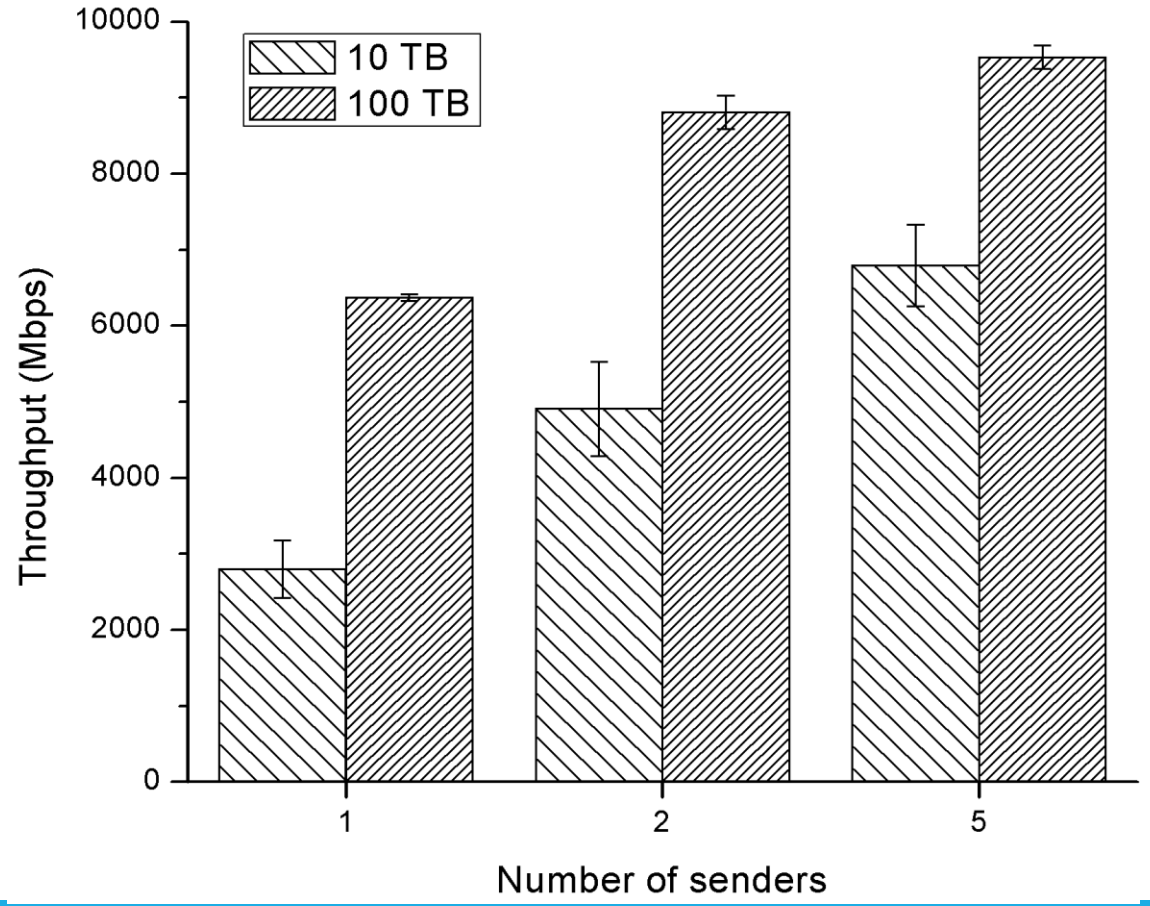
Scenario

- Single sender to a single receiver (FRA → MAD)
- Single-hop transmissions → only direct flights
- Multi-hop transmissions → exploitation of intermediate flights

Outcomes

- The throughput increases as the amount of data increases
- The transmission bottleneck is the optical fiber speed
- There is no big discrepancy between single-hop and multi-hop data transmissions

Throughput for many-to-one over 10TB and 100TB data



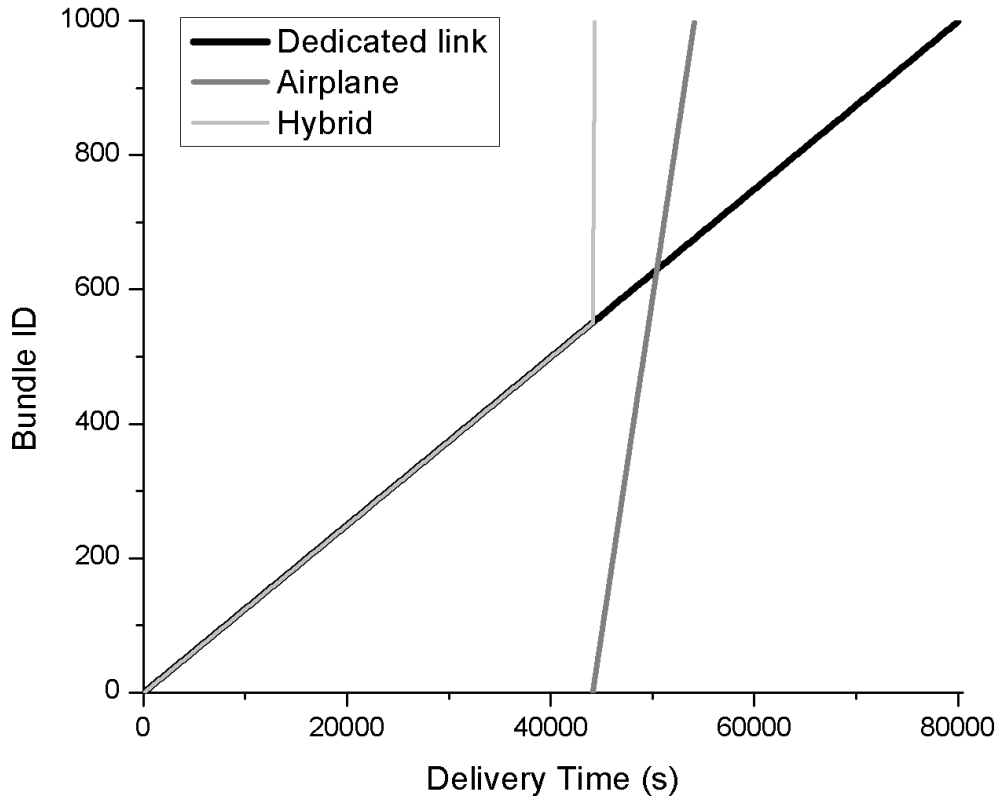
Scenario

- Many-to-one bulk data transmissions
  - Data deliveries from one, two or five research centers to one

Outcomes

- The usage of an aircraft as a transmission link, allows simultaneous transmission from different sources
- Limitation from optical fiber between airport and research center at destination
- Limitation from flights that arrive to the destination

Hybrid system



Hybrid system components

- Existing network infrastructure
- Proposed airline network

Scenario

- The dedicated ESA's link is 1Gbps
- Amount of data is 10TB

Outcomes

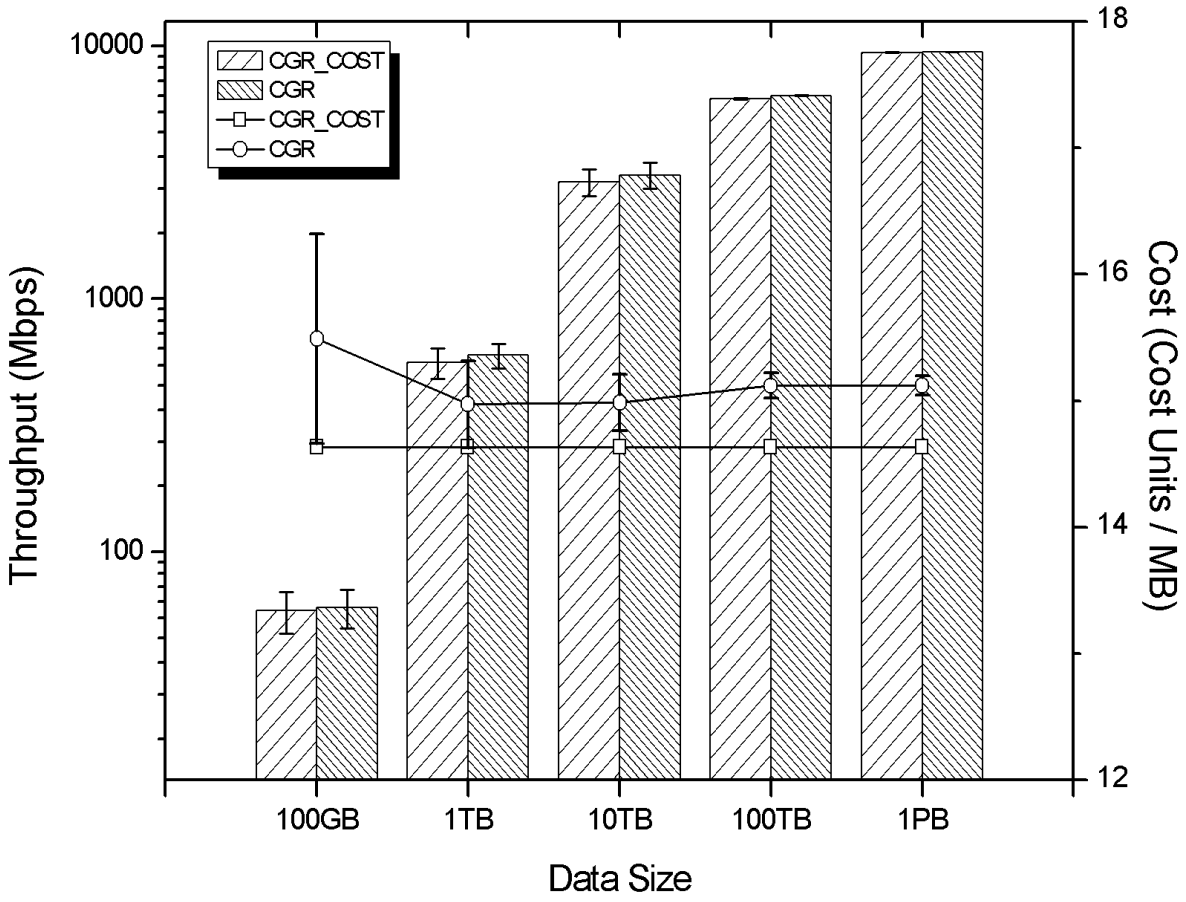
- Exploiting the hybrid system the bundles can be transferred via the faster mean
  - reducing the transmission time
  - reducing the congestion on dedicated Internet link

Contact Graph Routing (CGR) Algorithm

WITH DIFFERENT OBJECTIVE

- Different routing objective based on actual transferring cost
- Cost represents the transmission value per MB of the data delivered through the entire path from source to destination, including the air flights
- {FromNodeID, ToNode ID, Start Contact Time, End Contact Time, Transmission rate, Propagation delay, Cost}

Throughput over different data sizes and corresponding cost per MB



Scenario

- Usage of two different routing objective
  - Time
  - Cost

Outcomes

- The throughput is approximately the same
- Using as a routing criterion the cost, the cost/MB is maintained constant
- Using as a criterion the time, the cost/MB varies, depending in the available flights

Conclusion and Future work

- An acceptable level of service, in terms of throughput can be provided.
- A combination of the proposed system, along with the existing infrastructure could
  - reduce the transmission time
  - reduce the congestion
- Also, an alternative objective of routing policy can be used, in order to minimize the transmission cost

- Evaluation of the capabilities of the proposed architecture in a bigger scale by conducting a greater number of experiments with varying number of parameters
- Expansion of the architecture and remove the assumption that the research centers are located nearby airports
  - This is doable via the combination of bus or train transportation service.

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Thank you for your attention!

Questions