

## Scalable DTN Distribution over Uni-Directional Links

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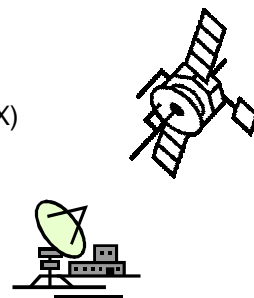
Kevin Loos <logic@tzi.org>

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2007-08-27, 京都、日本

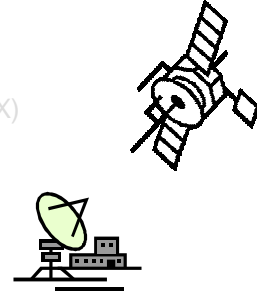
## Connecting Sparsely Populated Areas

- } Wireline (ADSL, fiber)
- } Terrestrial access network technology (WiMAX)
- } Terrestrial radio infrastructure for mobile communications (2G, 3G)
- } WLAN mesh networks
- } Satellite
- } Delay-tolerant store and forward



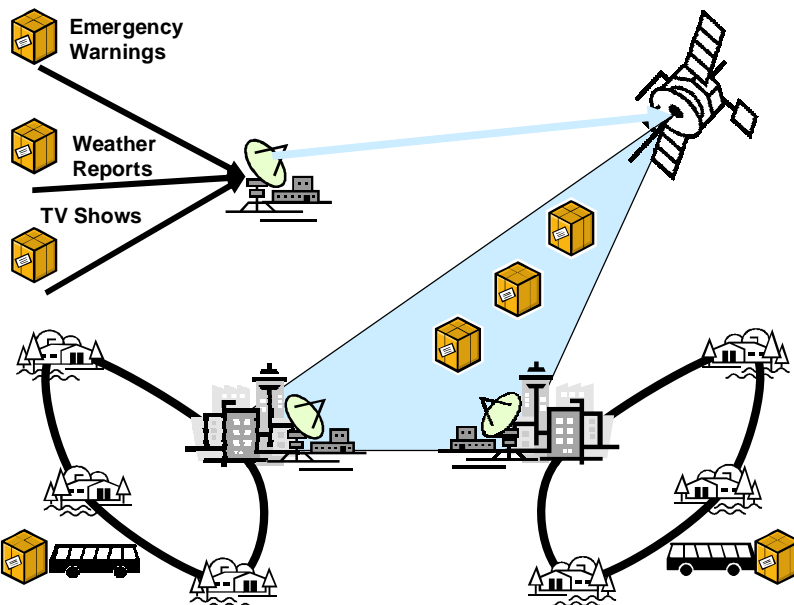
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- } Delay-tolerant store and forward

Combining scalable and timely satellite distribution with cost-efficient DTN-based forwarding at the edges



## First Mile Solutions: Sample Cost Calculation

} Connecting 15 schools in Cambodia

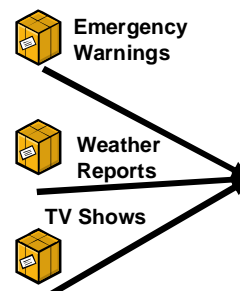
} Satellite for each school vs. hybrid approach based on Daknet

Satellite		First Mile Solutions	
Satellite	\$49,500	Satellite	\$3,300
Usage fee	\$54,000	Usage fee	\$3,600
Electric Generator	\$25,500	Electric Generator	\$1,700
Gas	\$77,376	Gas for Generator	\$5,158
Hub Master	\$54,000	Hub	\$699
		Hub Master	\$3,600
		MAP	\$2,995
		FAP	\$7,485
		Motor Man	\$6,000
		Antennas	\$3,300
		Gas for Motorcycle	\$2,418
		Motorcycle Maintenance	\$24
<b>Total Cost</b>	<b>\$260,376</b>	<b>Total Cost</b>	<b>\$39,979</b>

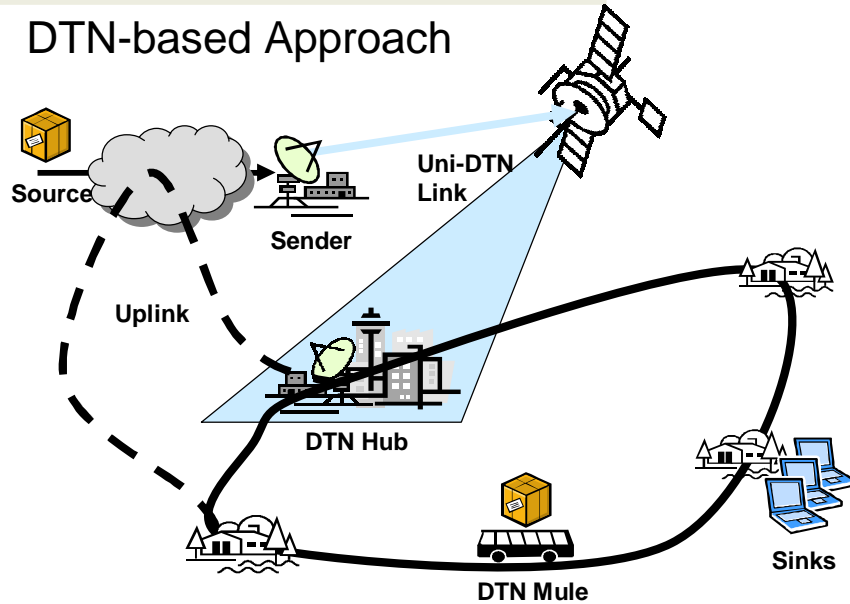
Source: First Mile Solutions Case Study

## Primary Use Cases

1. Distribution of Emergency Broadcasts
  - } Large-scale, immediate distribution of important safety information, warnings etc.
  - } Requirements: reliable and timely broadcast service
  
2. Content Distribution to Receiver Groups
  1. Large-scale push distribution of mass content to groups
    - } Requirements: multicast distribution of specific content
    - } Channel concept for content/source identification
    - } Reliable transport, potentially service classes (priority concepts)



## DTN-based Approach



## Components

- } DTN convergence layer for unidirectional transport
- } Multicast distribution approach

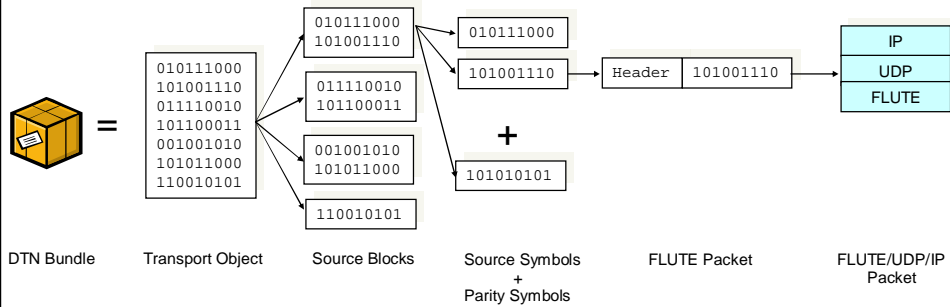
## Components

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## Uni-DTN

- } DTN convergence layer for unidirectional bundle transport
  - Leveraging FLUTE, one-to-n communication
  - FLUTE: RFC 3926: File Delivery over Unidirectional Transport
- } Intended for periodic (carousel) transmission
  - Forward Error Correction concept for additional reliability
- } Builds on Asynchronous Layered Coding (ALC) RFC 3450
  - Protocol Instantiation of Layered Coding Transport (LCT) RFC 3451
  - Receiver-based congestion control and FEC
- } In-band signaling of the transmitted resources
  - Metadata is carried in File Delivery Table (FDT)
  - Filename, content-type, FEC parameters etc.

## FLUTE Operation



## FLUTE as a Convergence Layer

- } Treat a bundle as a file
  - Filename is an ID consisting of sender EID, timestamp, and fragment offset
  - `uni-dtn://<seid>/<cts>/<cts-seq-num>/<frag-offset>`
  - Content-type: application/x-bundle

- } FDT extensions:
  - Destination-EID
  - Router-EID

- } Multiplexing multiple bundles in one FLUTE session
  - Map the class of service to bandwidth fractions
  - Reflecting bundle priority (bulk, normal, expedited)



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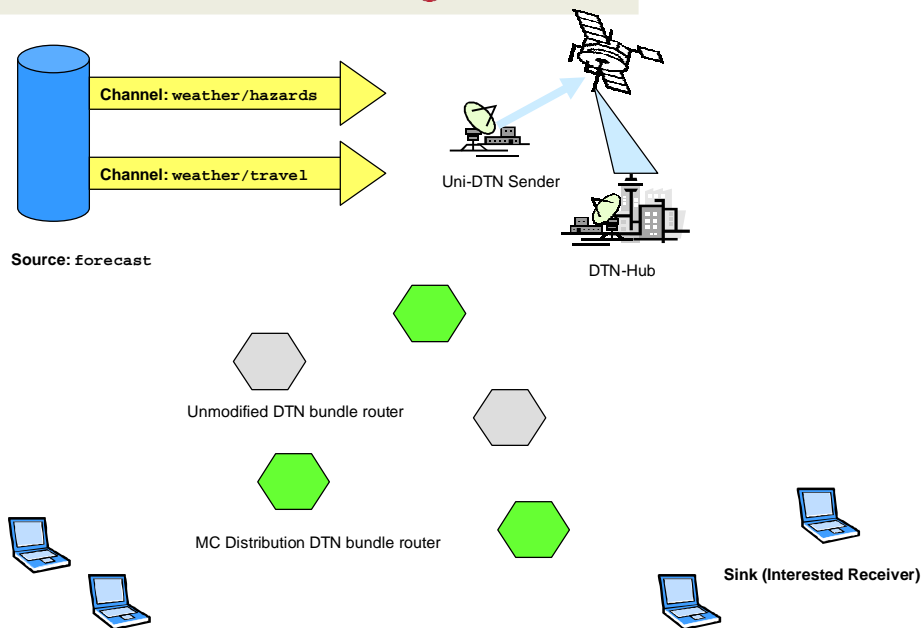
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001001010
101011000
110010101
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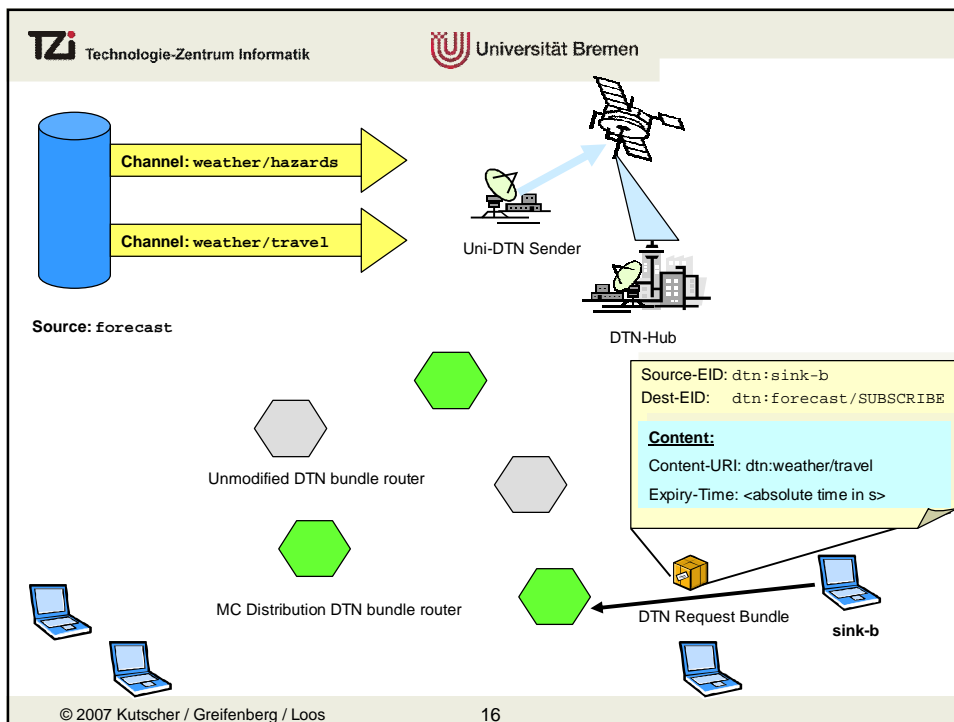
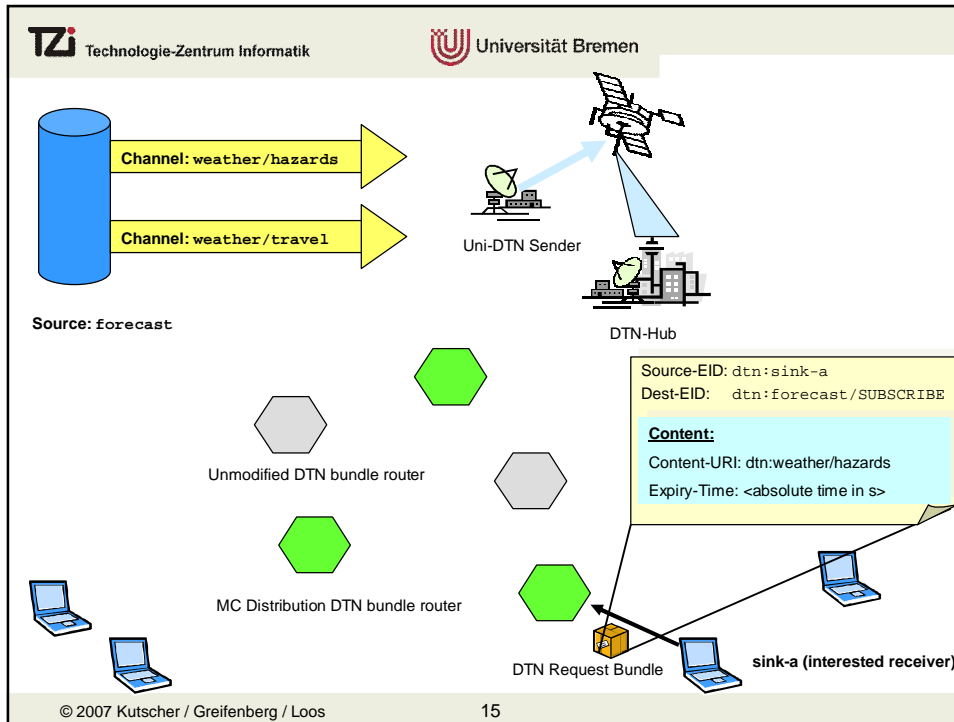
DTN Bundle

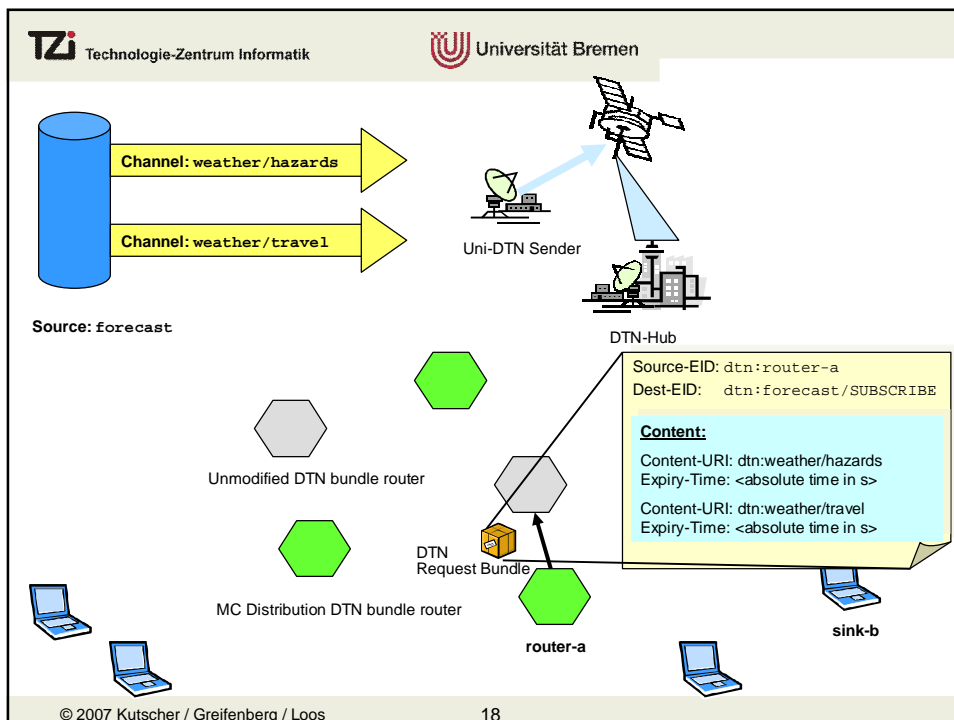
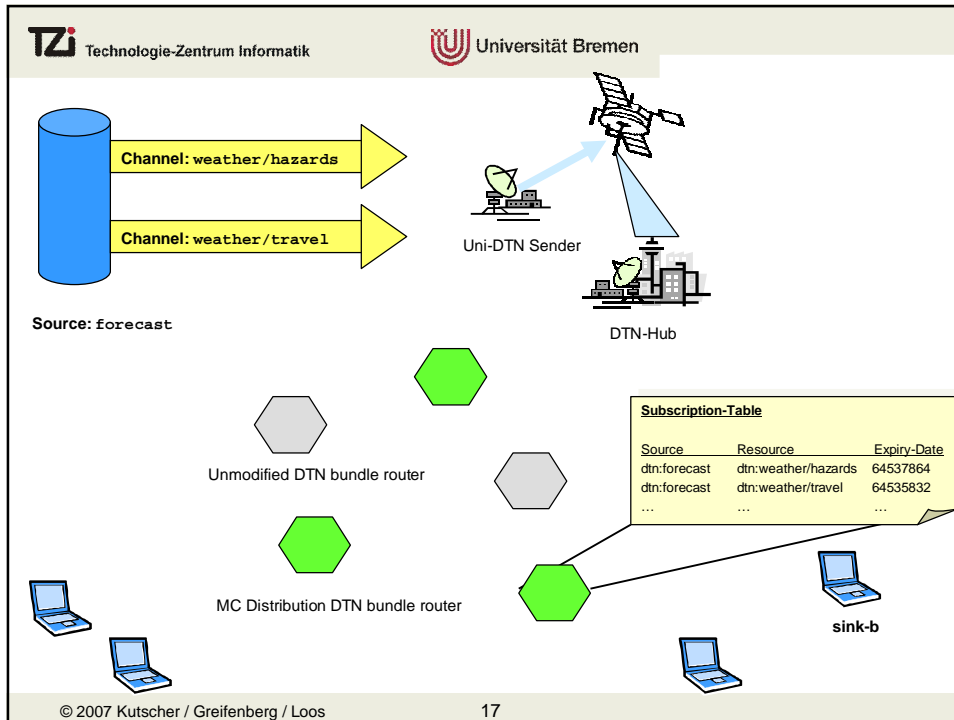
Transport Object

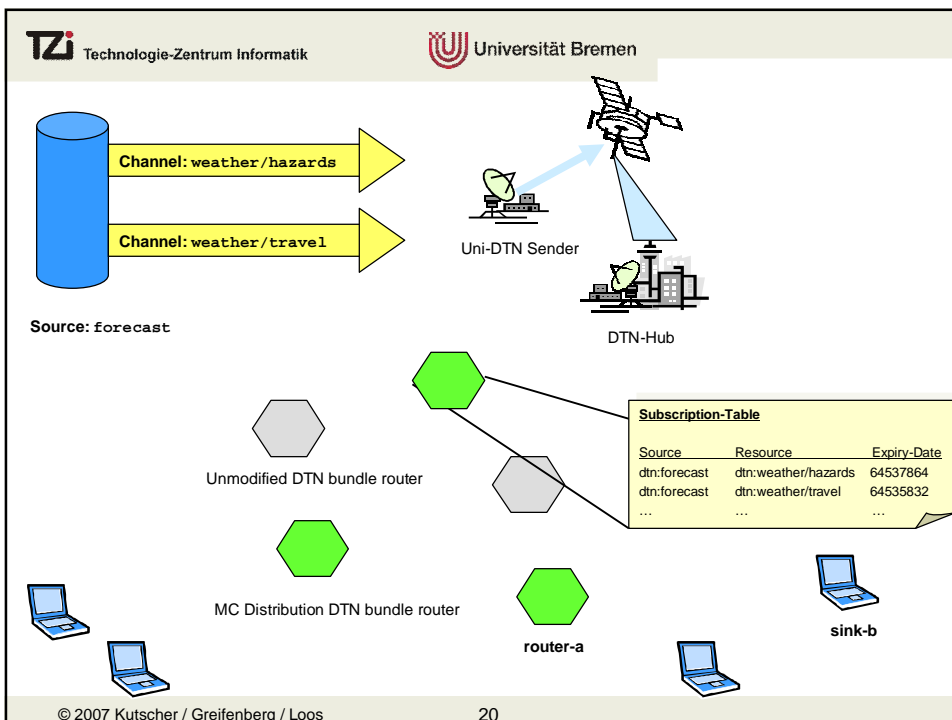
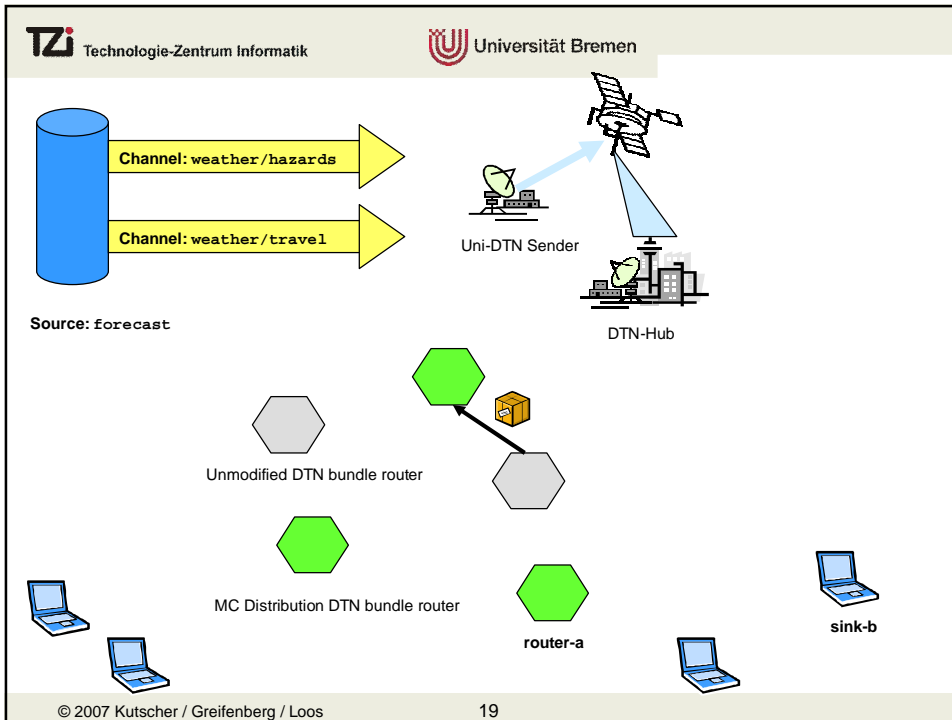
# Components

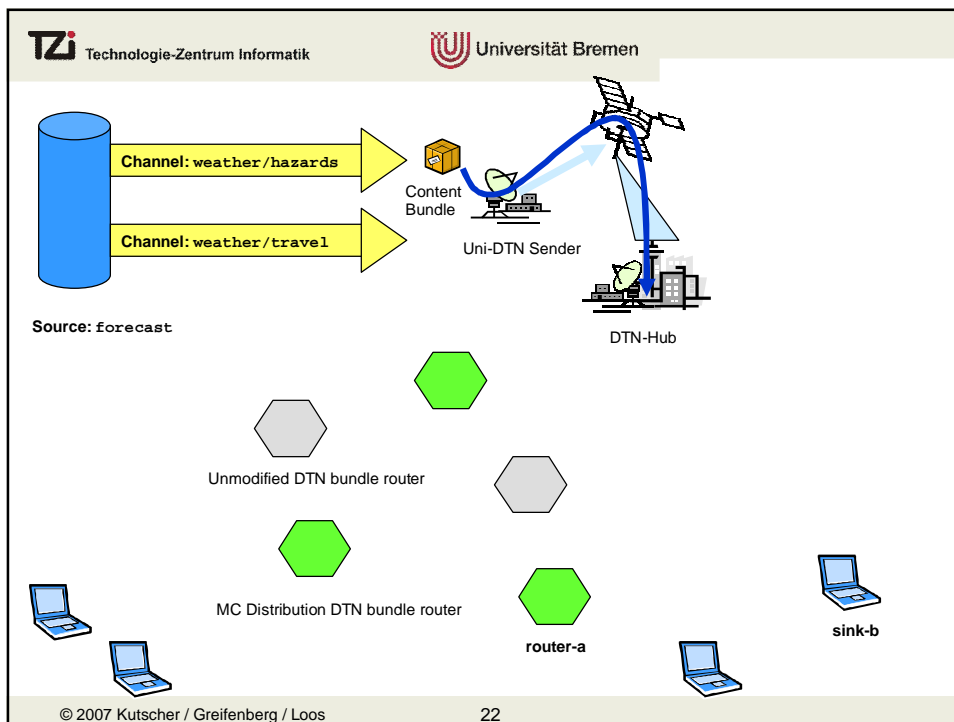
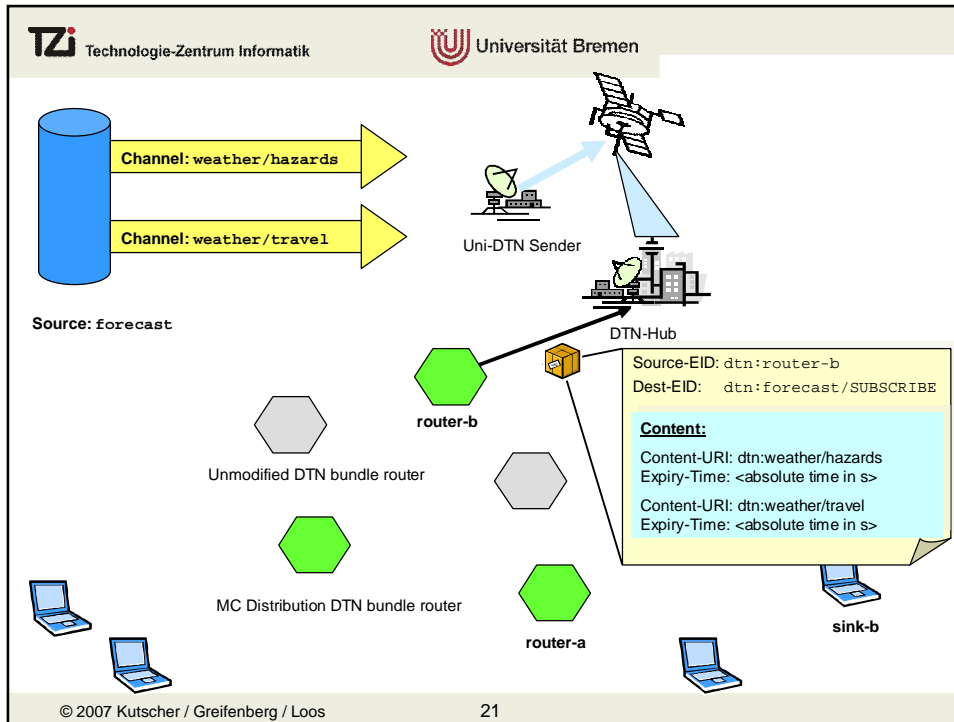
- } DTN convergence layer for unidirectional transport
- } Multicast distribution approach
  - Objectives:
    - § Simple regional distribution
    - § Do better than flooding
    - § Integrate with general DTN forwarding and unicast routing approaches

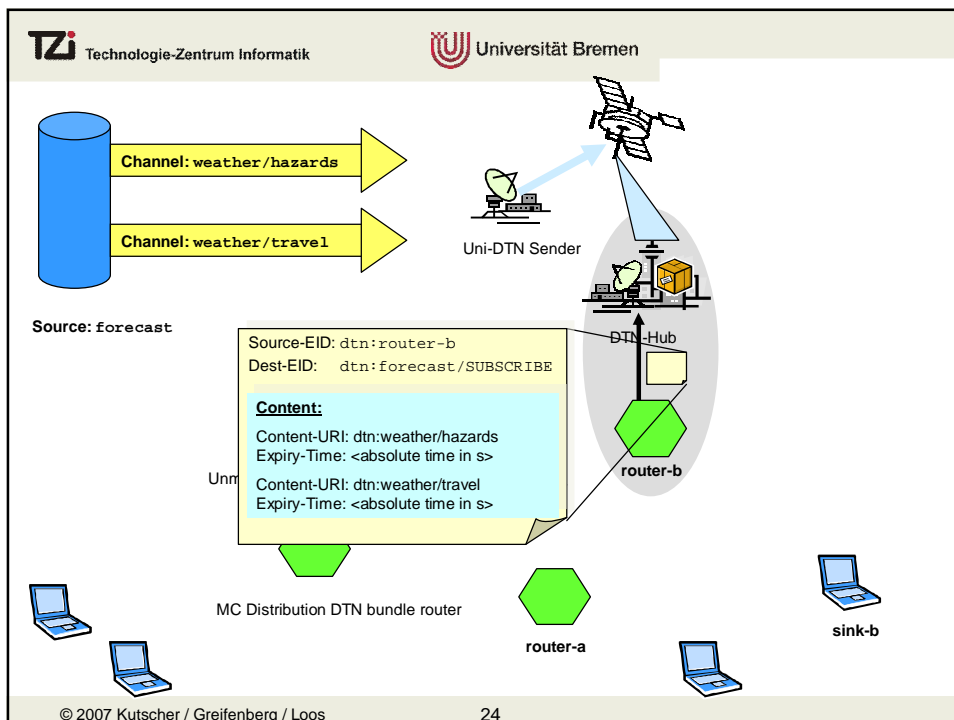
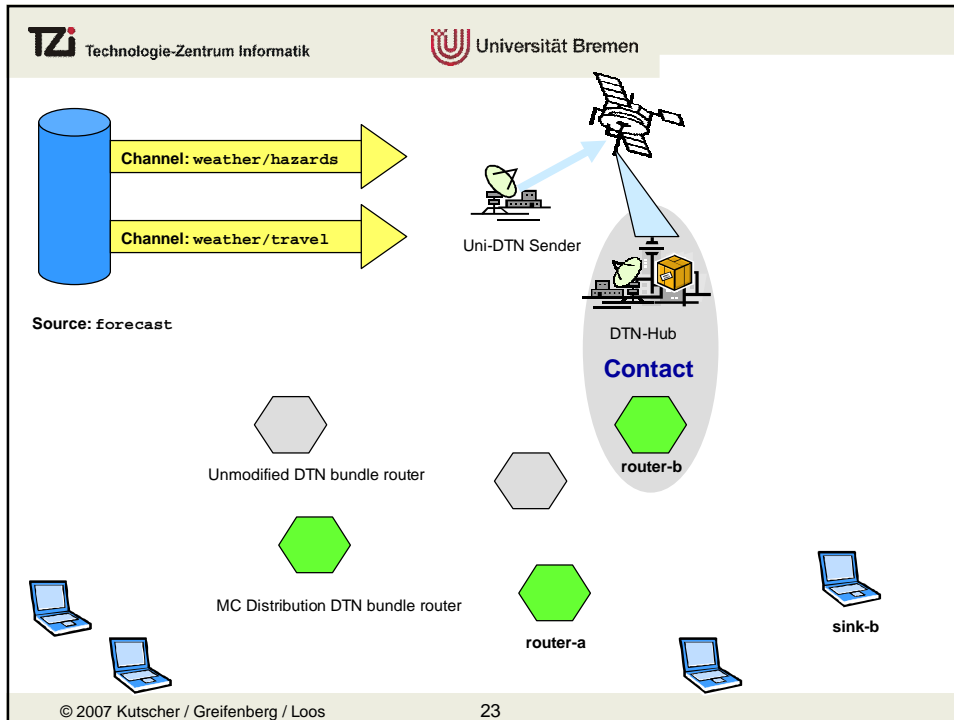


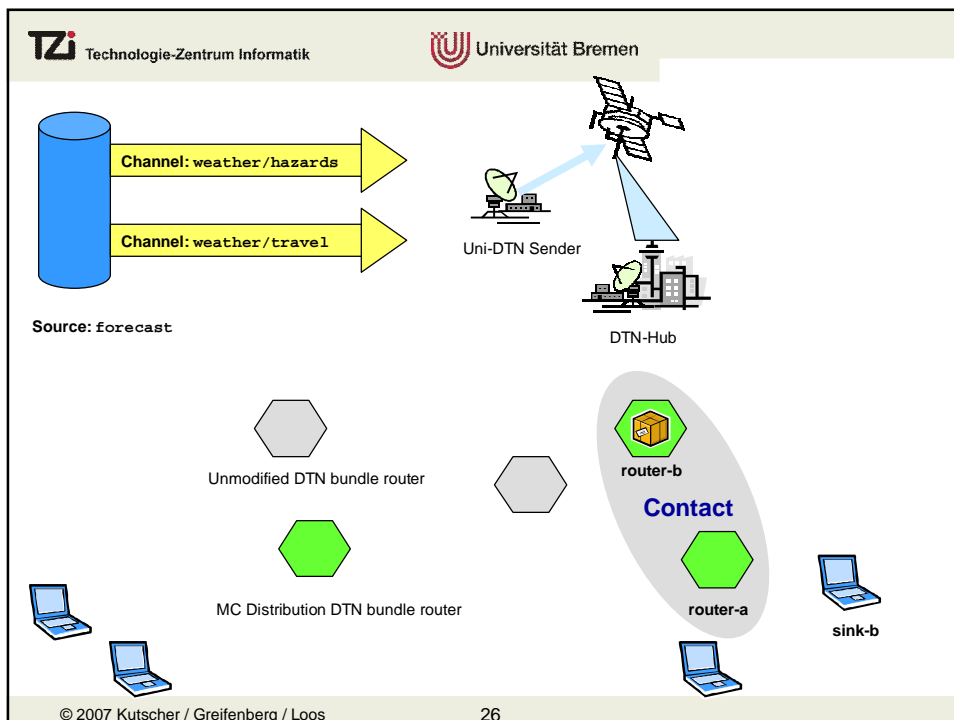
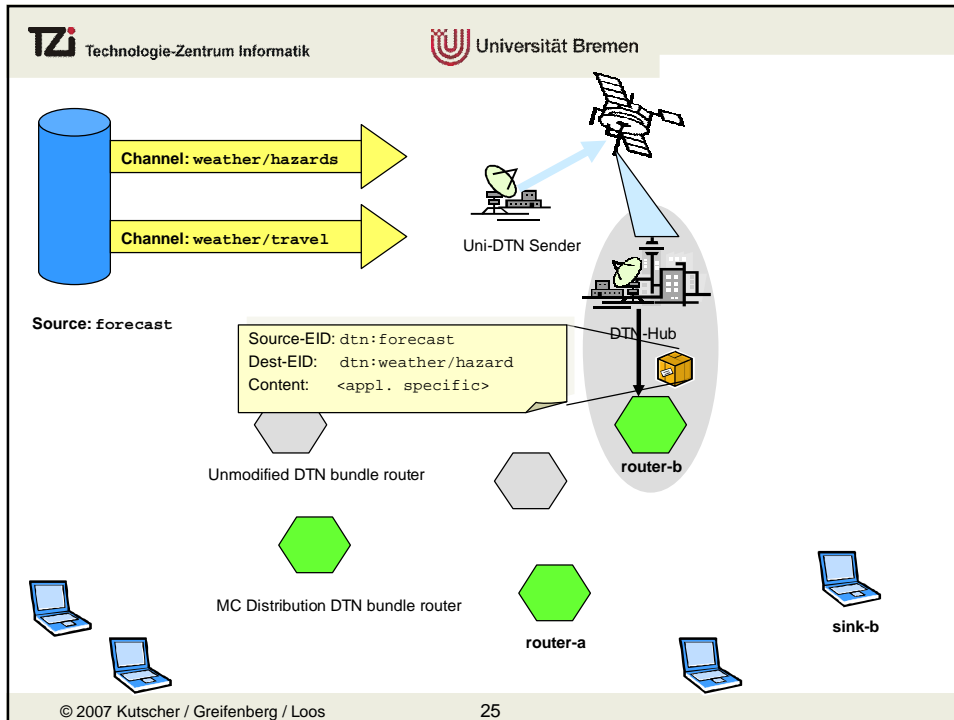


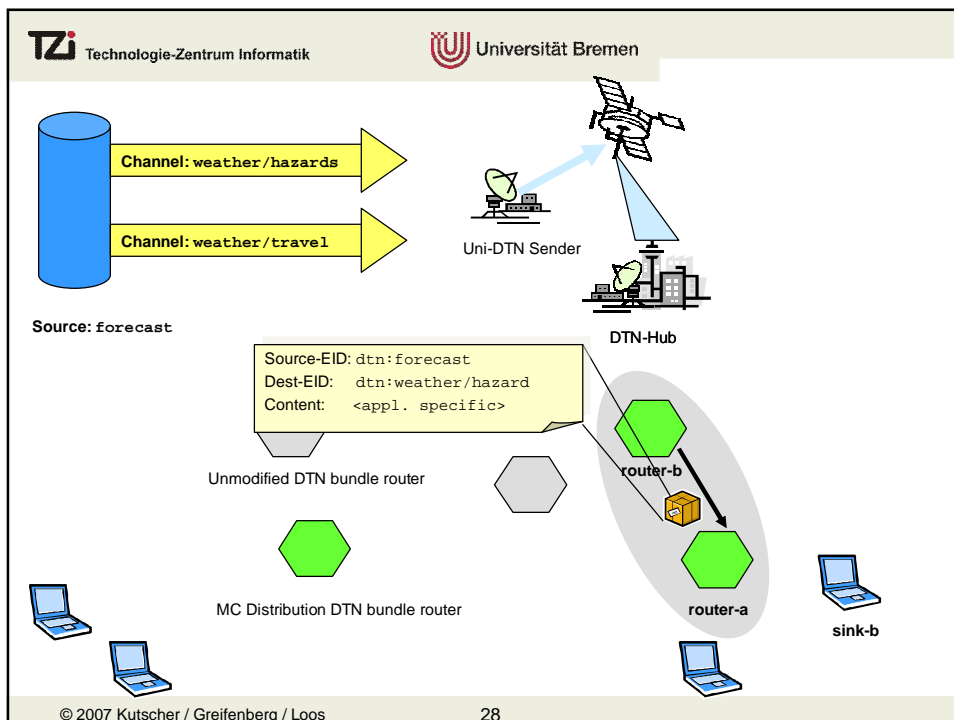
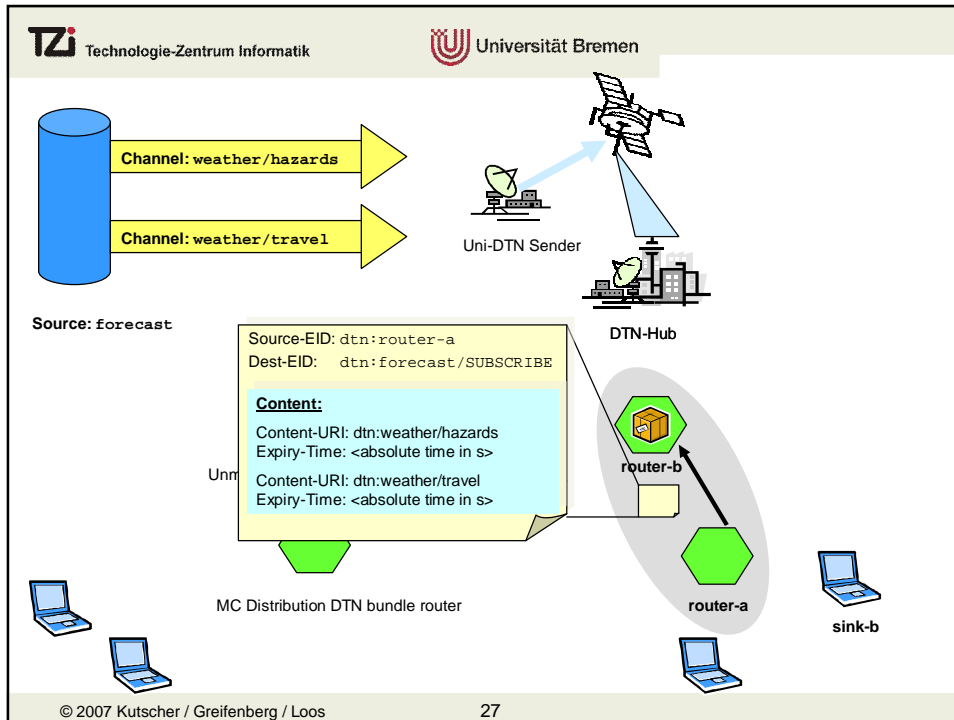


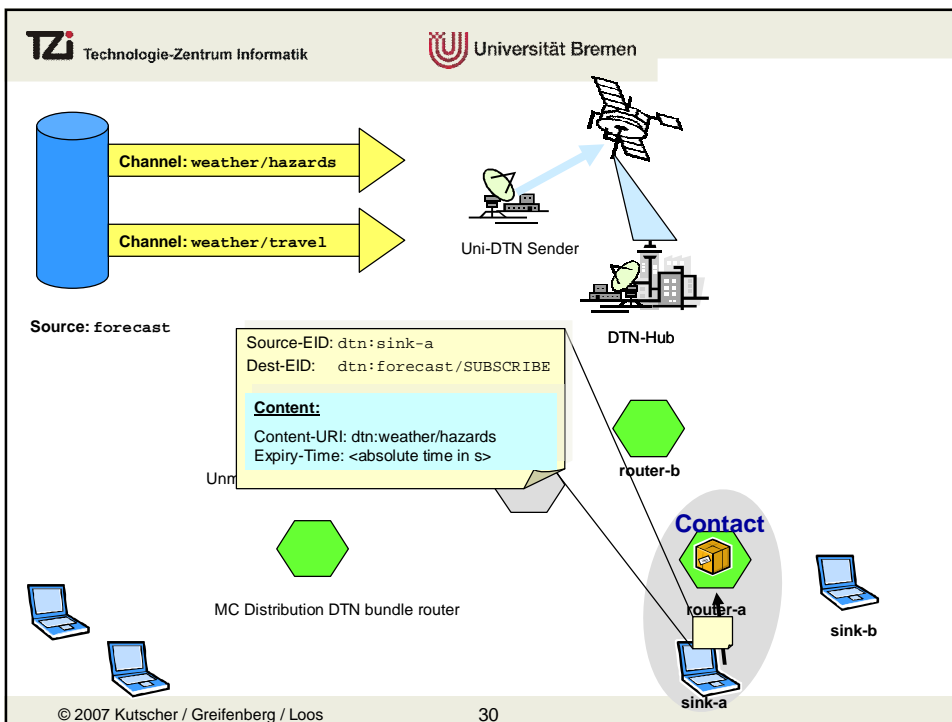
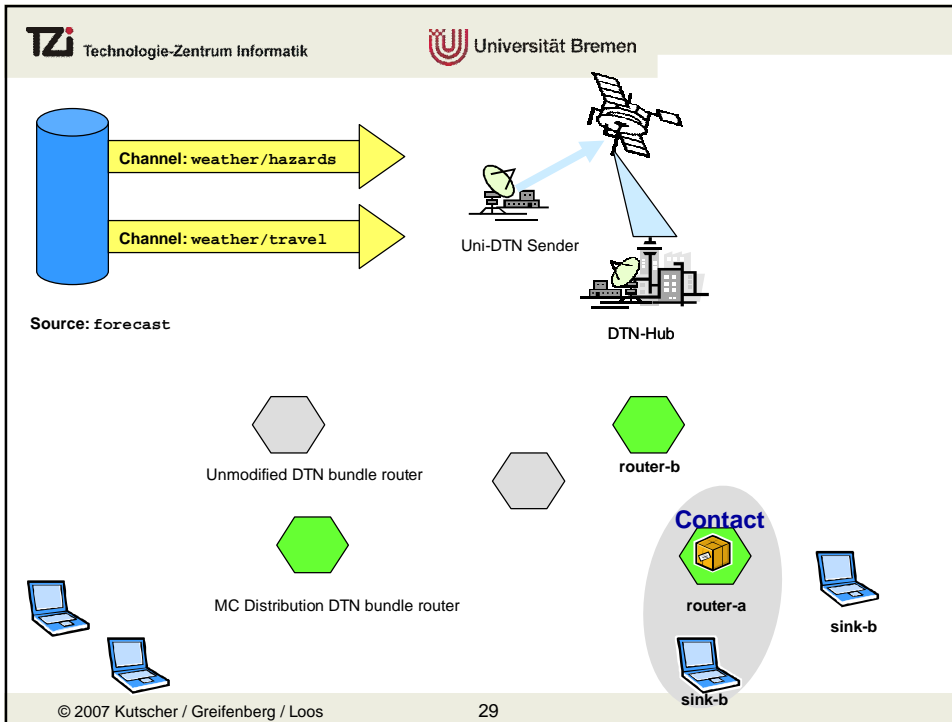


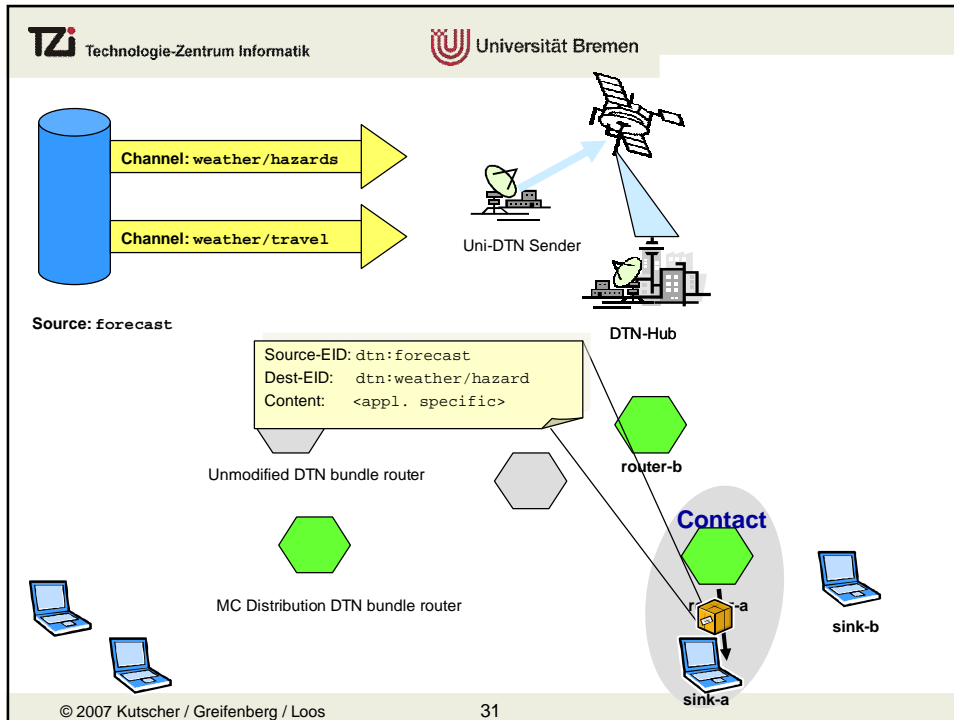












**TZI** Technologie-Zentrum Informatik **U** Universität Bremen

## Usage of DTN-EIDs

Source: forecast

Source-EID: dtn:router-a  
 Dest-EID: dtn:forecast/SUBSCRIBE

} Channel identifiers

- Used in subscription request bundles to specify desired content
- Used as destination EID for content bundles

} Source identifiers

- Source EIDs and origin identifiers for content bundles
- Used as destination EID elements for SUBSCRIBE requests
- Sources represent rendezvous point for multicast distribution

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## MC Distribution Routers



Subscription-Table		
Source	Resource	Expiry-Date
dt:forecast	dt:weather/hazards	64537864
dt:forecast	dt:weather/travel	64535832
...	...	...

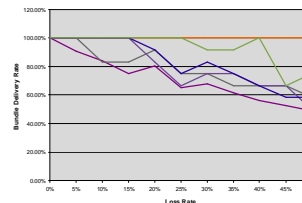
Source-EID: dt:sink-a  
 Dest-EID: dt:forecast/SUBSCRIBE

**Content:**  
 Content-URI: dt:weather/hazards  
 Expiry-Time: <absolute time in s>

- } Special processing and forwarding semantics for bundles destined to dt:\*/SUBSCRIBE
- } Maintain subscription tables for interested receivers
  - Aggregate subscriptions from multiple receivers (no receiver information stored in tables)
  - Forward aggregated subscription requests as DTN bundles
  - Limiting distribution of subscription requests by leveraging DTN unicast routing and subscription expiration
- } Exchange content bundles on contacts with other MC distribution routers

## Implementation and Evaluation

- } Papageno: TZI's FLUTE implementation
  - C++, open source
  - Stable and interoperable
- } RDTN: DTN bundle router implemented in Ruby
  - Work in progress, TCP, UDP and Uni-DTN convergence layers
  - Simple file interface for Uni-DTN
  - Working prototype of subscription-based multicast distribution
- } <http://prj.tzi.org/cgi-bin/trac.cgi/wiki/Uni-DTN>
- } Tests and Measurements
  - FLUTE performance can be assessed mathematically (with some assumptions)
  - Useful for pre-deployment planning and configuration
  - Additional measurements performed with bursty loss patterns



## Final Comments

- } Multicast distribution
  - Simple approach dedicated to content distribution in specific environments
  - Core components: Uni-DTN convergence layer, subscription-based Multicast distribution
  - Implementation status: working prototype
  - FLUTE-based CL useful in point-to-multipoint DTN communication scenarios
  - Applicable to wide range of networks (3GPP, DVB etc.)
  
- } Subscription-based DTN Multicast
  - Simplified model: source-specific multicast (channel linked to sender), non-custodial
  - Rely on DTN unicast routing for subscription forwarding
  
- } Comparison to other approaches, e.g., DTN Broadcasting (Karlsson et al.)
  - Channel concept without strict limitation of dissemination (left to hosts)
  - Our approach: limit content distribution to interested subscribers
  
- } End-to-end DTN-based information distribution
  - DTN-based distribution from source to receiver
  - Independent of specific broadcast distribution technology

ありがとうございました

Dirk Kutscher

<http://www.tzi.org/~dku/>

