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# Global IP Network Mobility

## using Border Gateway Protocol (BGP)

# BGP Network Mobility

- Connexion Service Summary
- Current IP Mobility standards
- Network and Service Challenges
- BGP as a mobility solution
- Questions



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# Enabling 2-Way Onboard Communications Services…

## To Passengers:

- **Real-time, Internet Access**
- **VPN Support**
- **Connectivity throughout their travel experience**
- **Extending commonly known hotspot connection method**
- **Television to Singapore Airlines in 2005**

## To Airlines:

- **Simple cabin design**
- **Reliable and robust system**
- **Use wireless to reduce weight & power**
- **Real-time crew information services**
- **E-Enabled Aircraft Initiatives**

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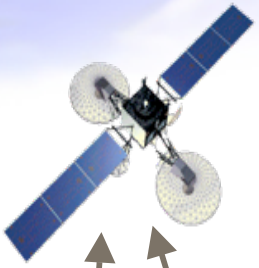
# 802.11 HotSpot In The Sky

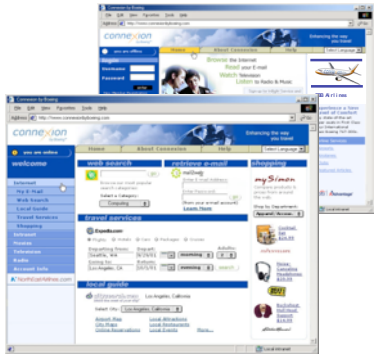

Notional representation

# Connexion by Boeing – System Architecture



Data Transceiver & Router

Core Network Unit



Antenna

Antenna Controller



Ground Stations

Internet

Enterprise & Network Operations Centers



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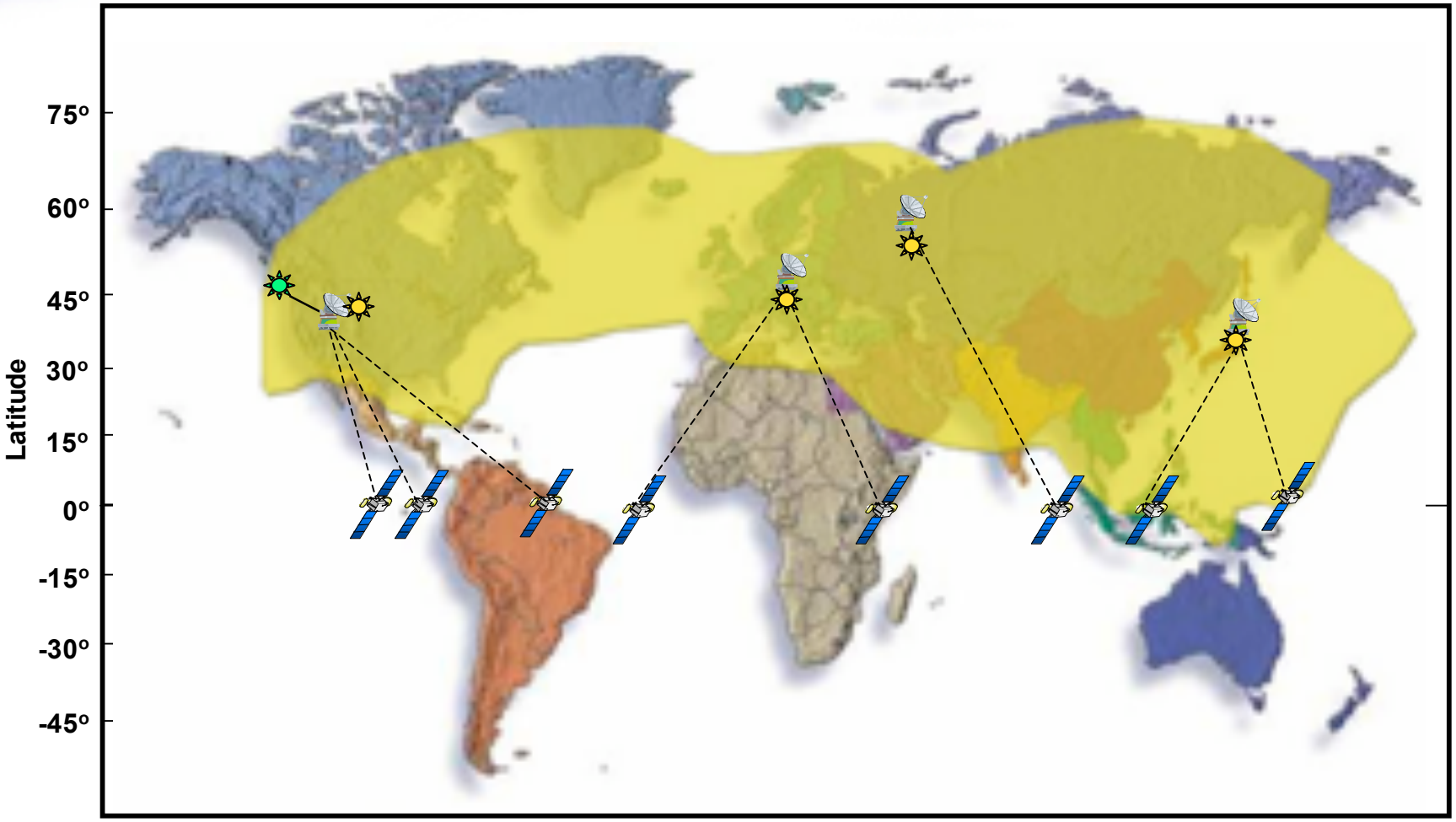
# 2004 Service Region




Ground Station

Satellite

Network Operations Center (NOC)

Ground Station & Data Center

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# Current Mobility Standards

- Target host mobility rather than network mobility
  - Mobile IP protocols for IPv4 & IPv6
  - Require mobility support in protocol stacks
- Do not provide “intuitive routing” over a wide geographic area
- Network Mobility only being seriously addressed in IPv6, through the NEMO working group. NEMO Basic Support Protocol (under development) relies heavily on IP tunneling
- Routing optimization is limited to within a BGP autonomous system

# Network & Service Goals & Challenges

- Our network challenges are unique in a number of areas
  - Our platforms move,
    - But not just a little…they also move fast
    - Hosts remain stationary with regard to the platform
    - Hosts may number in the hundreds
  - A typical flight between Europe & Asia will use 3 different ground stations and 4 satellite transponders within half a day
  - Leads to a desire for seamless handoff between satellite transponders and between ground stations



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# The Latency Tax

- Using BGP allows us to directly influence traffic within the Internet as a whole and not just within our own network
- Mobile IP protocols are not optimized for the vast distances that a jet aircraft normally travels in a single day. Most rely on tunneling & static homing which adds large latencies when the mobile router is not near the home router
- For Example: Latency with an aircraft homed in Europe currently over east-Asia to an Asia website - one-way
  - 320ms – Aircraft -> geo-synchronous satellite -> ground East Asia
  - 130ms – Asia -> North America
  - 70ms – East Across North America
  - 80ms – North America to Europe
  - 80ms – Europe to North America
  - 70ms – West Across North America
  - 130ms – North America -> Asia
  - 30ms – Within Asia
  - 890ms Total
- Almost 2.7 seconds to complete a TCP 3-way handshake!!!

# Finding a better path through the ether…

- Find a better way to route traffic, reduce latency, improve network reliability, and allow for global connectivity
- Static homing & tunneling solutions would require us to provision a substantial global IP backbone to carry the backhauled traffic. These WAN costs would be substantial
- The solution needed to allow seamless user connections throughout a flight
- The solution needed to leverage existing routing technology, couldn't require outside networks to make changes to accommodate our mobile platforms & needed to be acceptable to network operators worldwide
- In general, traffic flows should follow geography!
- Our solution: Leverage BGP
  - Natively supported worldwide
  - Uses the global routing table for mobility
  - Selective announcement and withdrawal mobile platform prefixes as the platforms move



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# Fighting Latency Back

- Instead of having mobile platforms homed to a specific geographic network, send & receive the mobile network traffic to & from the Internet at each satellite ground station
- For Example: Aircraft dynamically homed in Asia to Asian website
  - 320ms – Aircraft -> geo-synchronous satellite -> ground East Asia
  - 40ms – within Asia
  - 380ms Total
- 1.1 seconds to complete a TCP handshake
- 1.6 seconds or 56% reduction TCP handshake time



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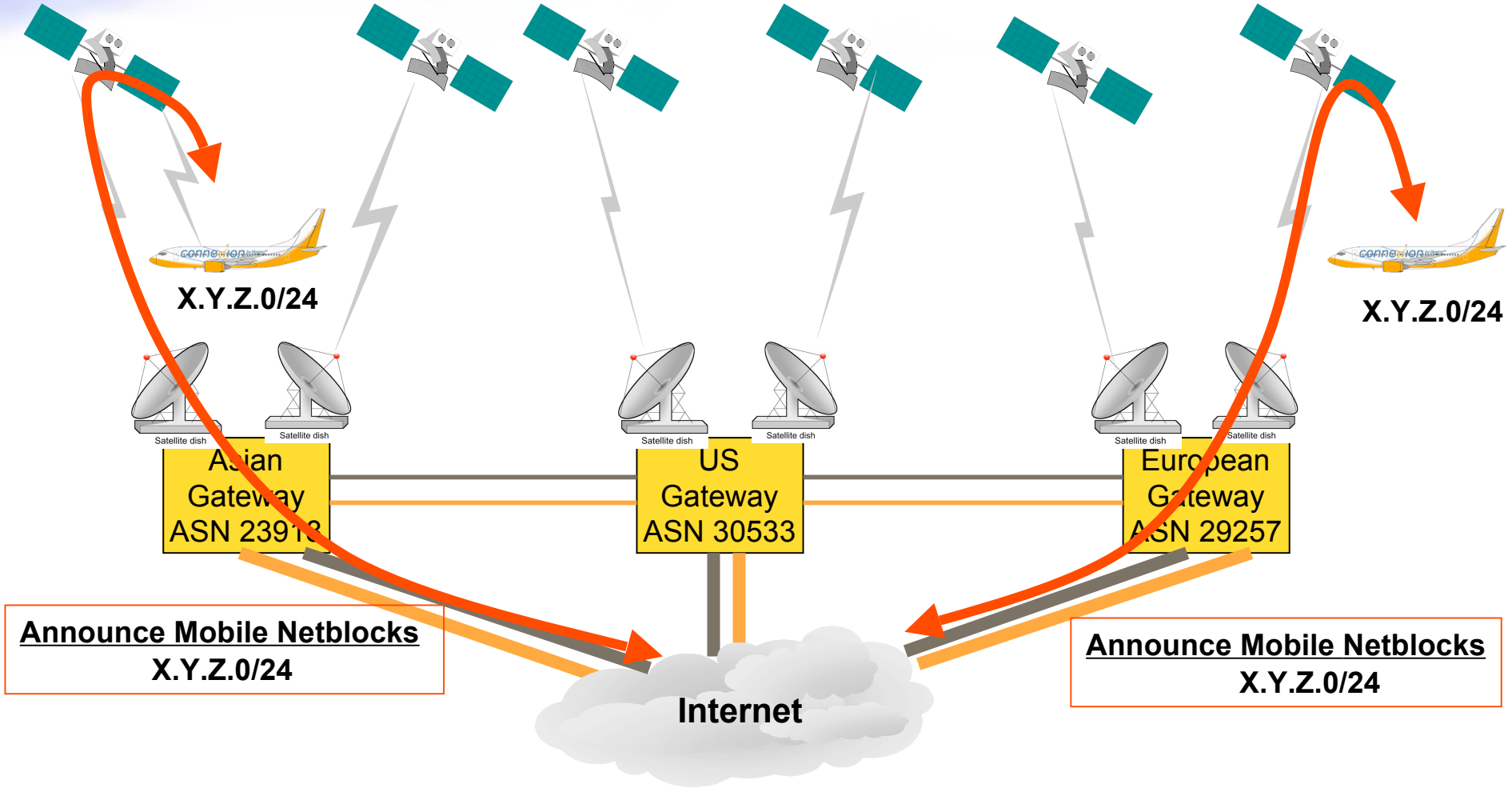
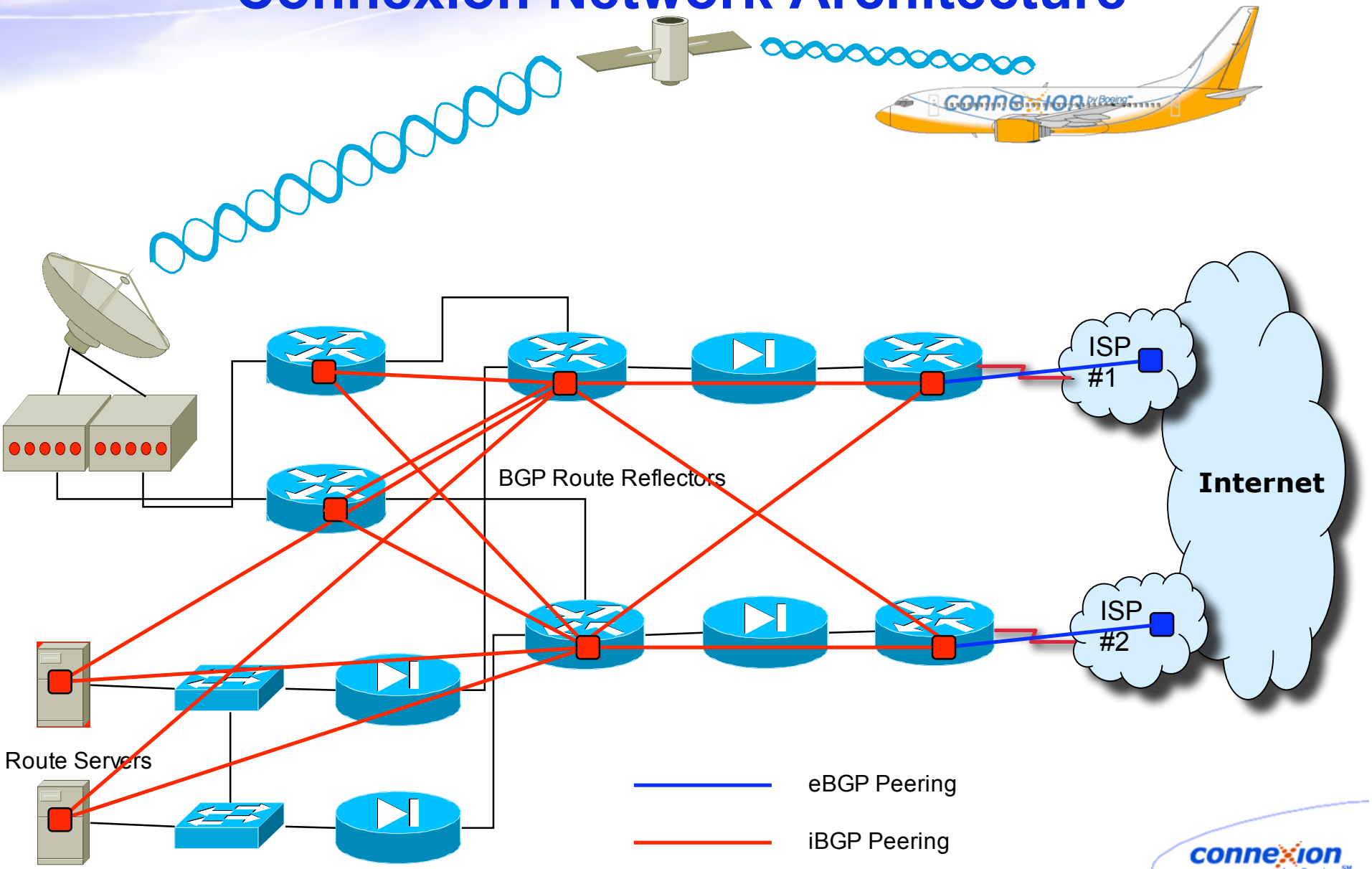
# Using BGP for mobile routing




**Commercial passenger traffic is released at each ground station**
**Each ground station only advertises the IP's for the planes it is serving.**
**When a plane leaves a region, that gateway stops advertising its IP's.**

# Connexion Network Architecture



# Challenges using BGP for Mobility

- /24 network propagation
  - Concerns about the growing number of BGP routes in the global default free zone have caused some network providers to filter smaller route announcements
  - We currently advertise a /24 address block for each mobile platform. Testing of route propagation found that most providers will accept and propagate our /24 announcements
  - In the event that some providers don't accept our /24 announcements we are advertising a larger aggregate containing all of the mobile platforms
  - We only really require all of our Internet providers to exchange our routes among themselves, mobile platform routes could be filtered at the edge of the network without a loss of connectivity

# Challenges using BGP for Mobility

- BGP convergence vs. handoff time between ground stations
  - Our testing has shown that the period of time required to achieve 2-way communications on a new satellite transponder is complementary to the time BGP will converge on global providers
- Provider concerns
  - Prefix churn
    - route changes happen only a few times a day
    - As a percentage of total global route-updates our updates are very small
  - Prefixes may have an “inconsistent” origin ASN
    - Currently originates at the active ground station
    - Changes when platform moves…
    - … but does not originate from two places at once



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# Prefix Transition in Action

- An actual Lufthansa flight from East-Asia to Europe
  - November 17, 2004 01:00 -> 19:00 UTC
- BGP update collectors located throughout the globe collected mobile platform BGP updates as seen from their point of view
- This shows the transition process from one ground station to another
  - Each number on the plot represents a BGP autonomous system
  - Red spots represent the originating autonomous system numbers
- BGP data modeling and extraction provided by the route-views project from the University of Oregon
  - http://www.routeviews.org/



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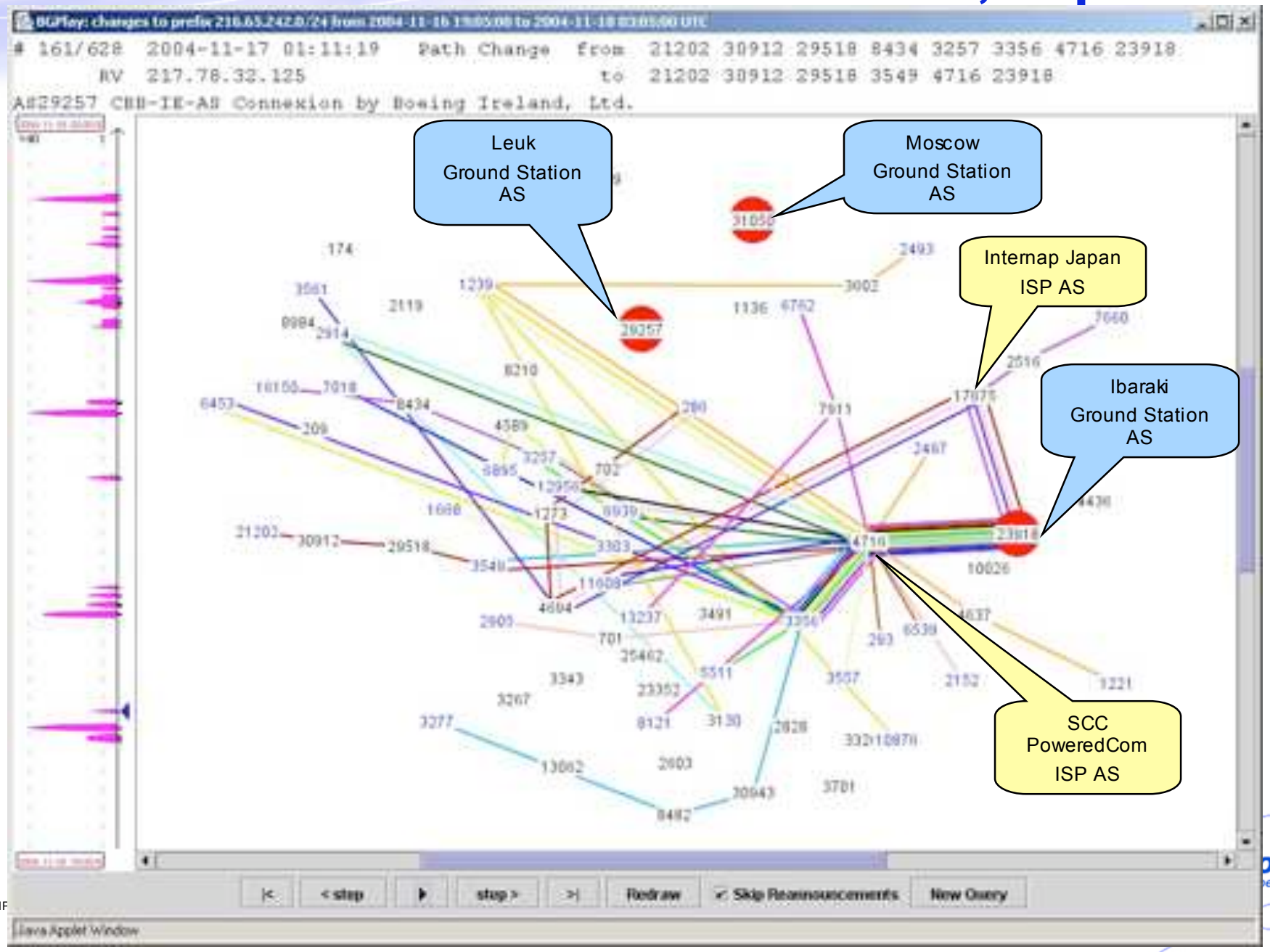
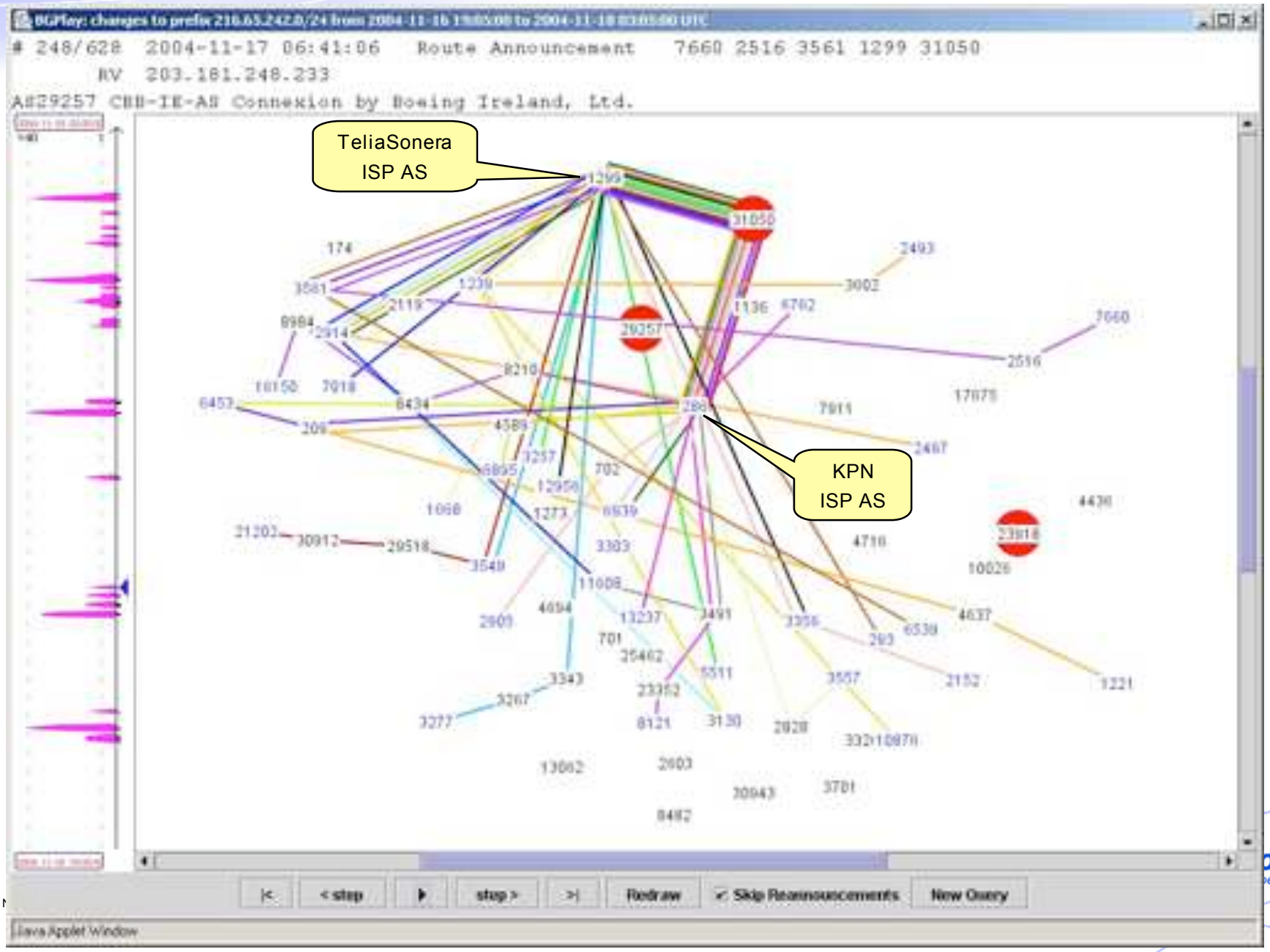
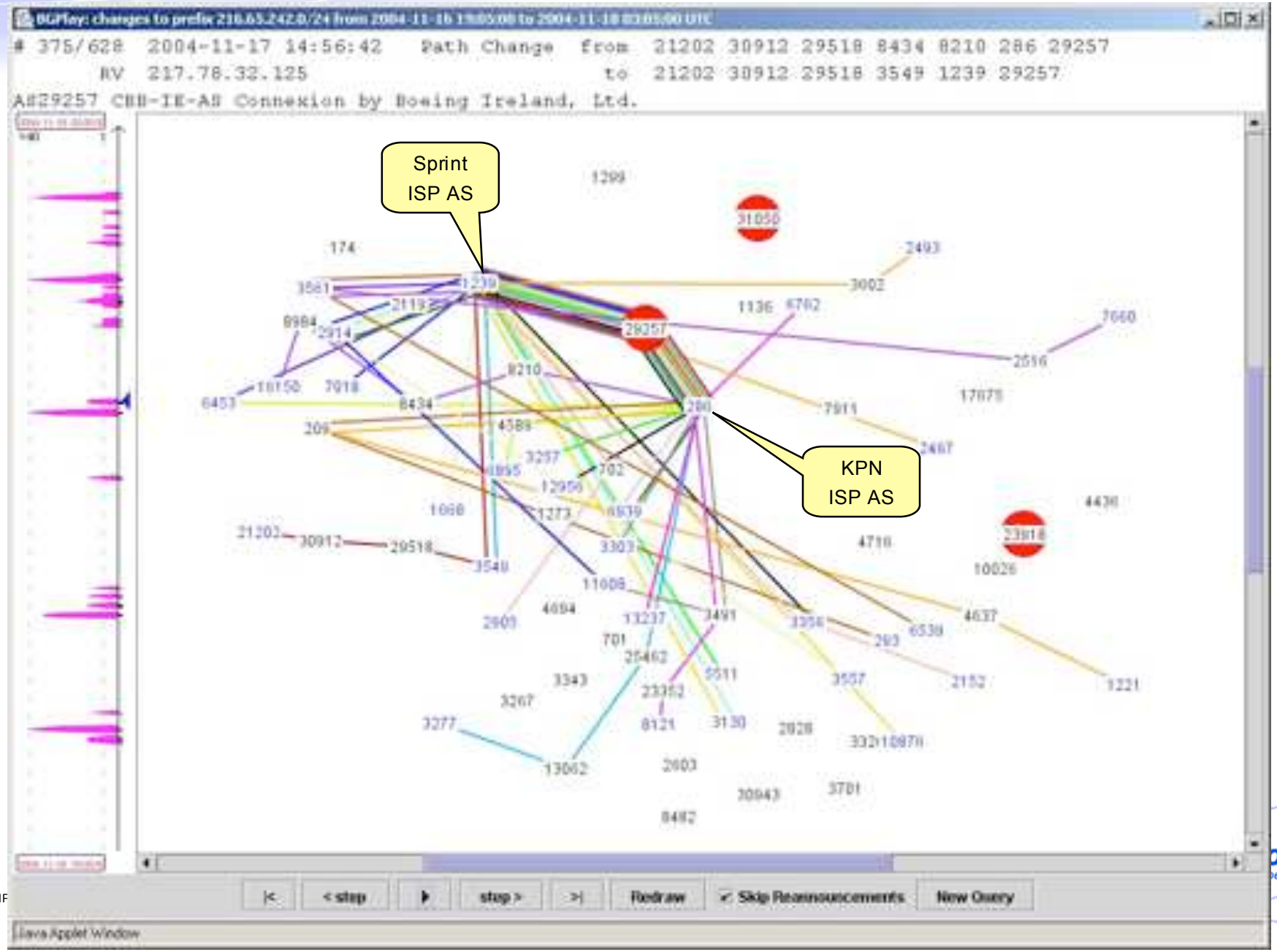
# Routes Announced from Ibaraki, Japan



# Routes Announced from Moscow, Russia



# Routes Announced from Leuk, Switzerland



# Route Flapping and Dampening

- Route Flapping and Dampening
  - Will our routes be dampened by some providers?
  - Testing & research has shown that a single route update is unlikely to cause a route to be dampened by core networks. We see some dampening after about 5 changes within a short period of time. Dampening for global network operators is also not as popular as it used to be
  - We always announce a stable aggregate “safety net” for our mobile platforms to ensure a stable path from the dark corners of the Internet
  - Satellite handoff within a ground station: A ground station may serve more than one satellite transponder. When a handoff occurs within a ground station, we do not propagate a route withdrawal beyond our autonomous system

# Future Prefix Management

- Dynamic Prefix Management
  - A system that could allow for mobile platforms to “lease” address blocks for the duration of a “flight”. Similar to DHCP for hosts. This will allow for more efficient use of address space
- Regionalization of address space
  - Address blocks can also be regionalized. Certain “flights” generally stay within the service of a single ground station
  - By noting which “flights” will be served by a single ground station, we can then assign address space from a larger aggregate which is tied to the ground station. This will allow us to not announce specific blocks for flights when they are not needed

# Conclusions

- BGP as a Mobility Solution
  - Does not require special IP stacks on customer hosts
  - Does not require special routing onboard the mobile platform
  - Does not require any special treatment of BGP attributes
  - Does not require special operational support from peers
  - Only suitable for /24 and bigger networks

•Special thanks to all members of the Connexion Network Team

Gordon Letney, Andrew Dul, Terry Davis, Carlos Montes, Ben Abarbanel

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Thank you
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