Global IP Network Mobility
Using Border Gateway Protocol (BGP)

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Connexion by Boeing Service Summary

Current IP Mobility Standards

Network and Service Challenges

BGP As A Mobility Solution

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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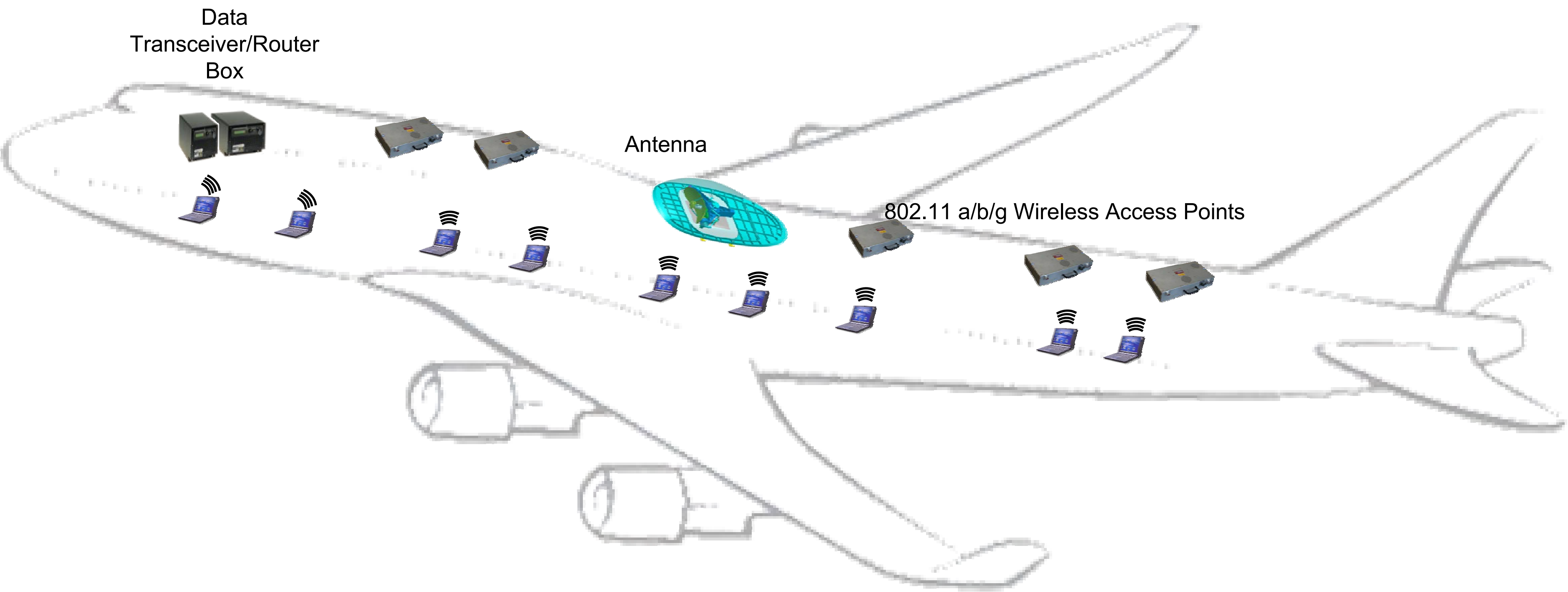
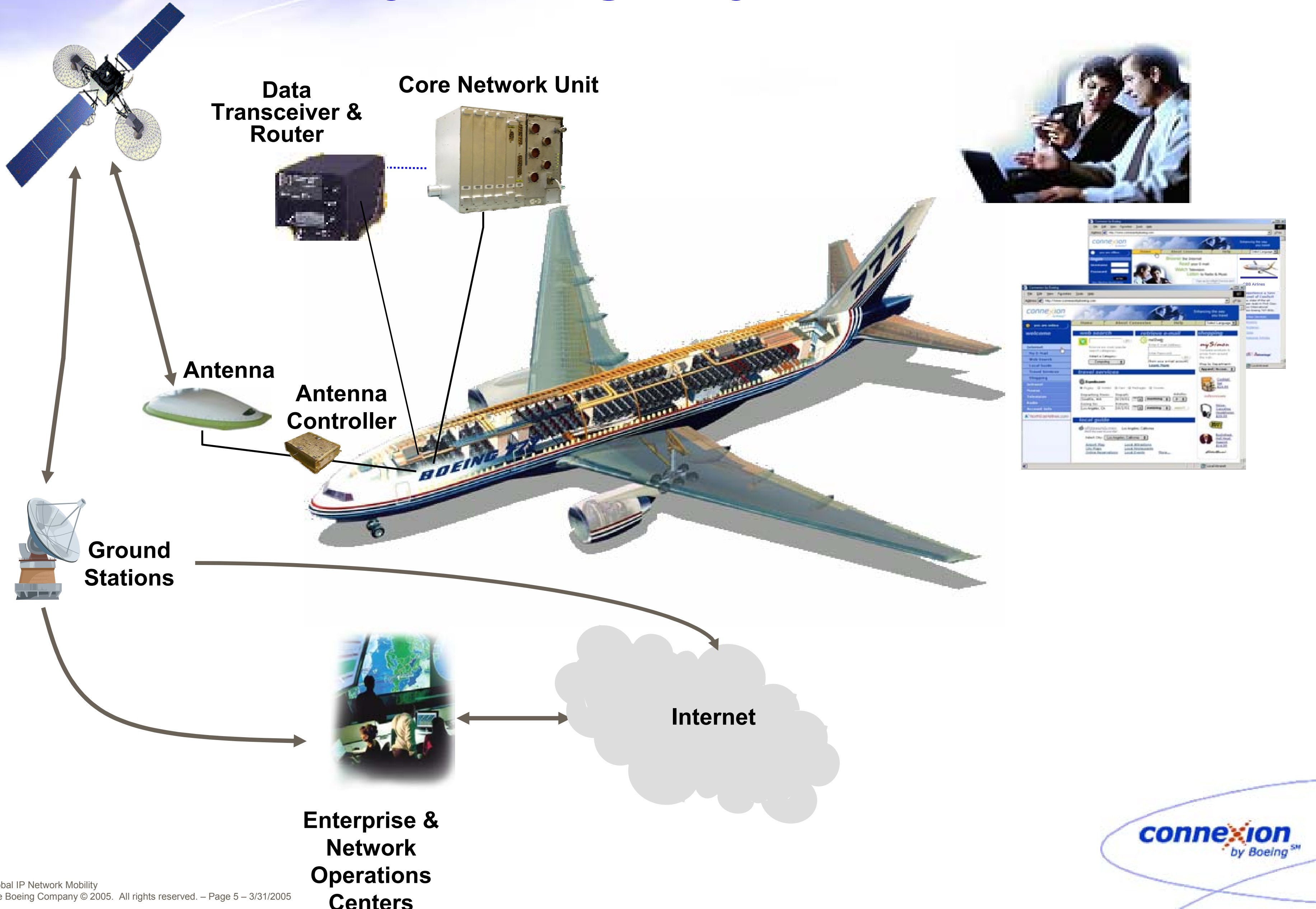
802.11 HotSpot In The Sky

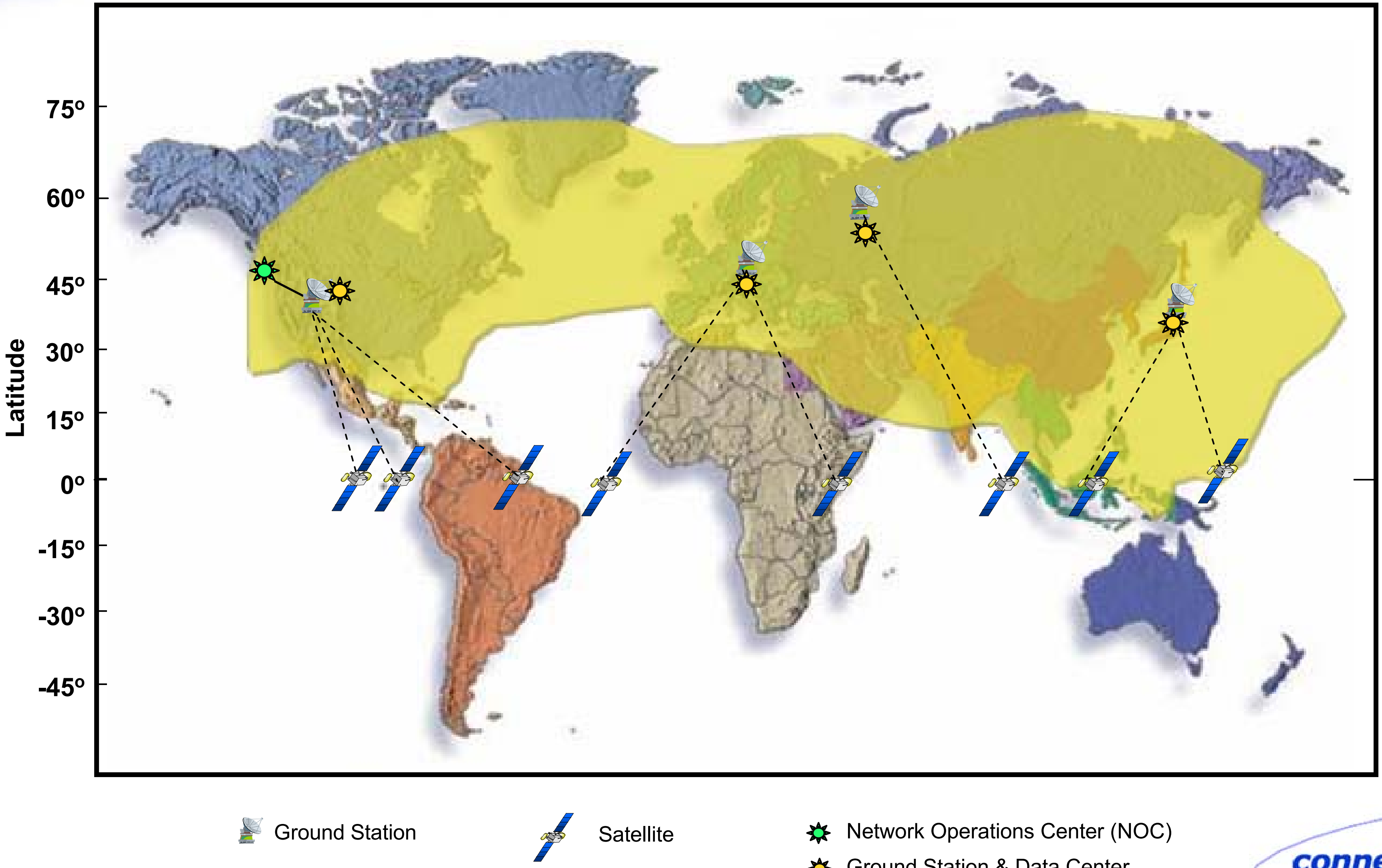


Notional representation

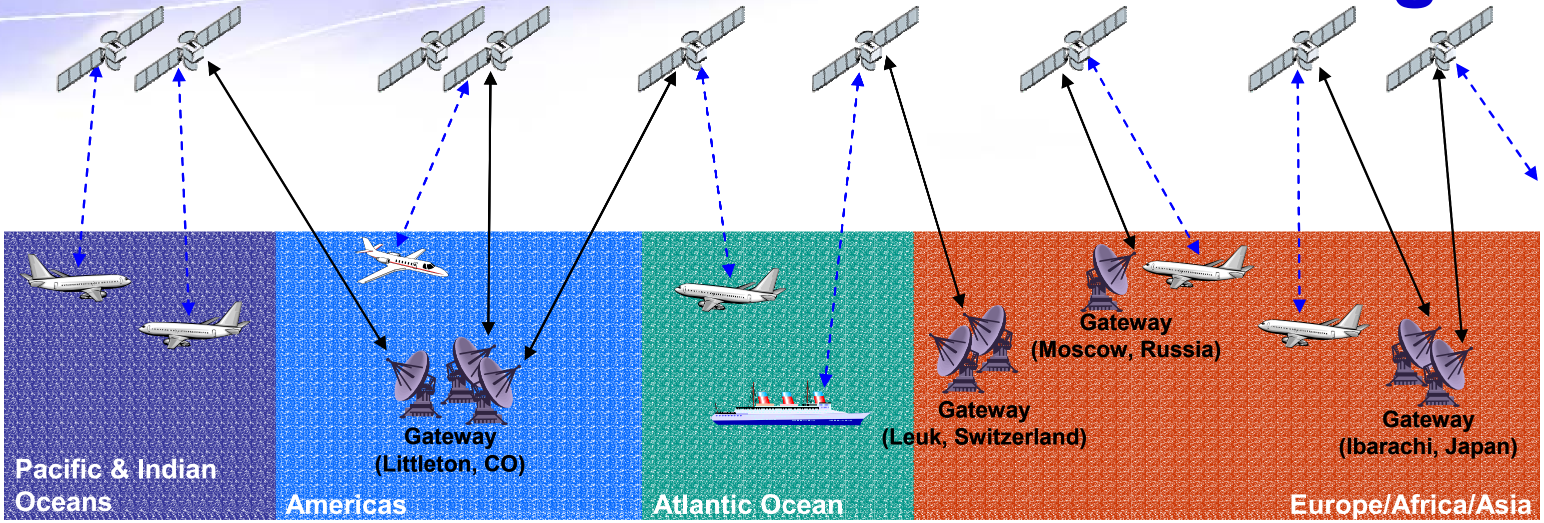
Connexion by Boeing – System Architecture



2004 Service Region



Network & Service Goals & Challenges



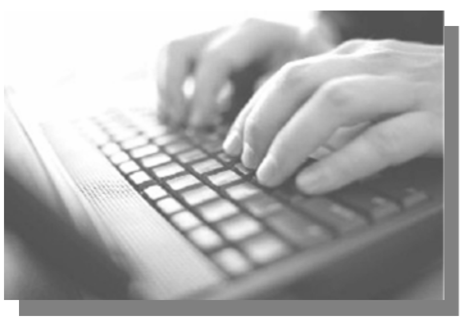
- Our network challenges are unique in a number of areas
  - Our platforms move,
    - But not just a little…they also move fast
    - Hosts remain stationary with regard to the platform
    - Hosts may number in the hundreds
  - A typical flight between Europe & Asia will use 3 different ground stations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

Current Mobility Standards

- Focus on 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 (RFC 3963) relies heavily on IP tunneling
  - Global HA HA draft (draft-thubert-nemo-global-haha-00.txt) is a first start for true global mobility
- Routing optimization is limited to within an autonomous system without full operational adoption of a NEMO standard

The Latency Tax

- 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
- Almost 2.7 seconds to complete a TCP 3-way handshake!!!



- For Example: Latency with an aircraft's home agent 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

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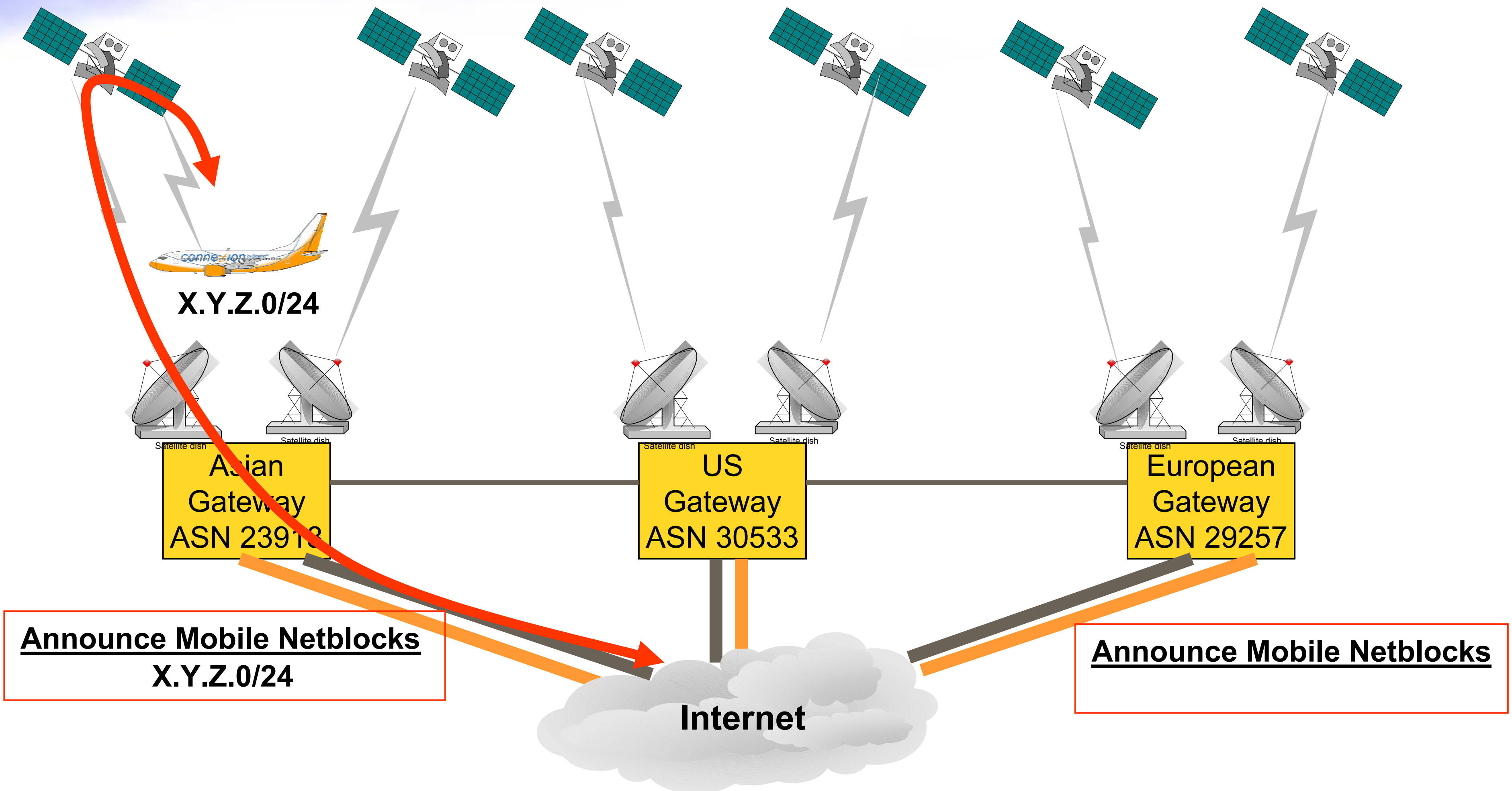
Finding a better path through the ether…

- 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 as much as possible!

- Our current solution: Leverage BGP
  - Natively supported worldwide
  - Uses the global routing table for mobility
  - Selective announcement and withdrawal of mobile platform prefixes as the platforms move
  - Routes are originated by route-servers in the terrestrial network

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.

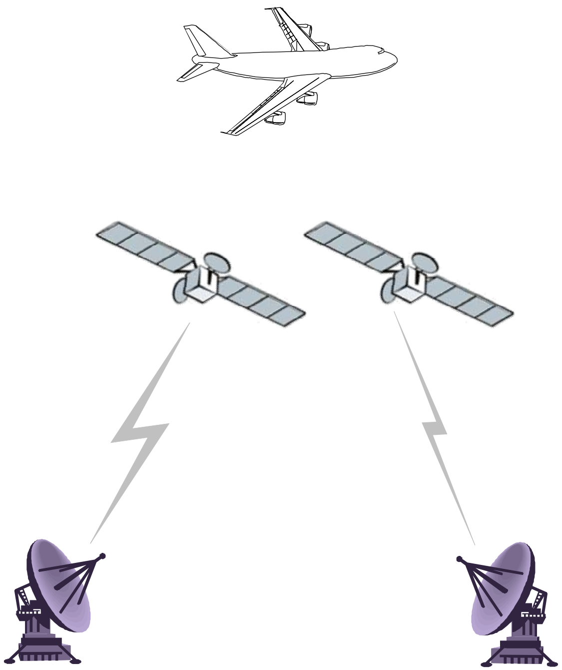
Fighting Latency Back – Best Case

BGP Allows Direct Influence of Traffic Within the Internet As A Whole

- 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
- 1.1 seconds to complete a TCP handshake
- 1.6 seconds (59%) reduction in TCP handshake time

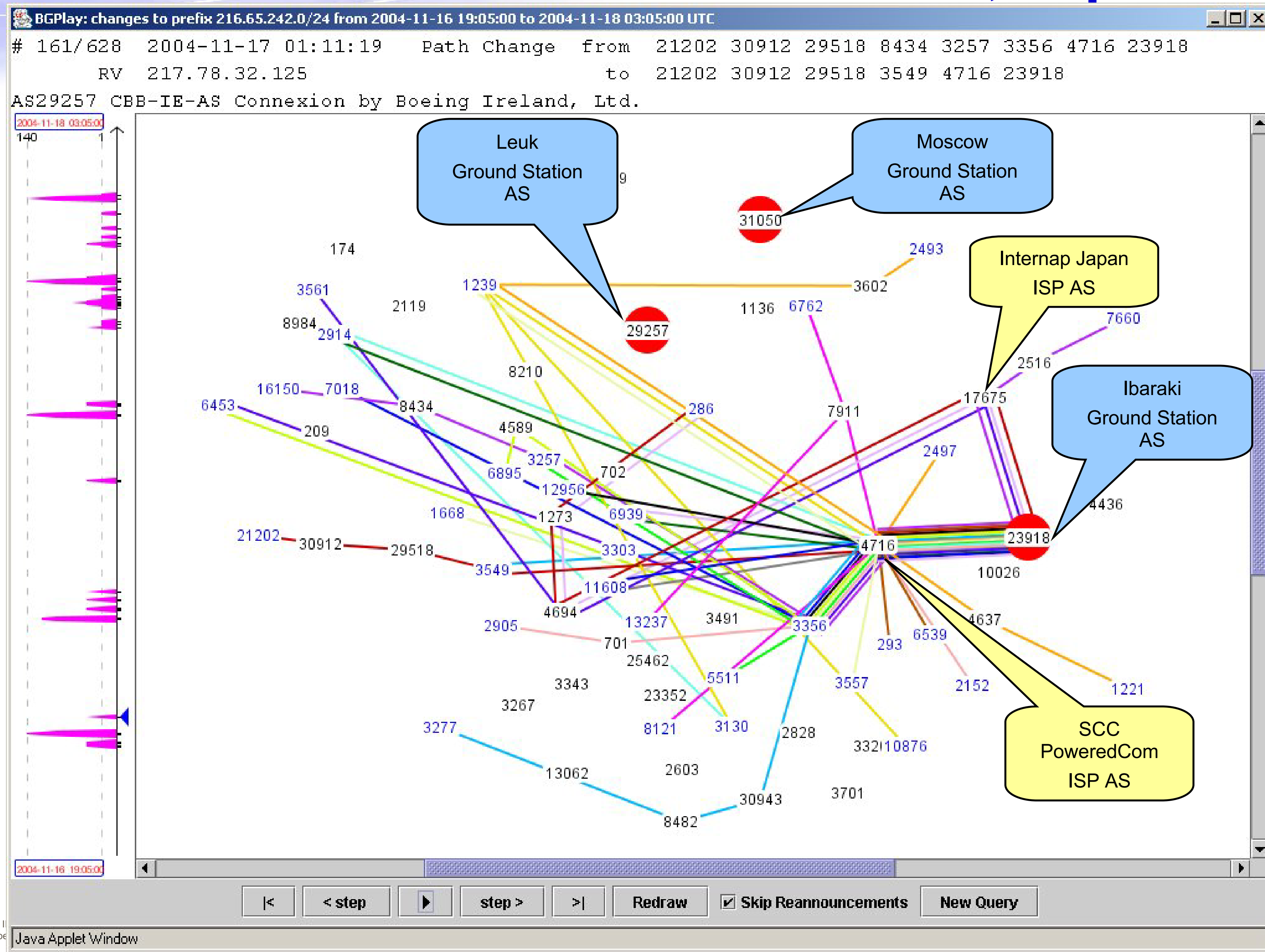
- For Example: Aircraft dynamically homed in Asia to Asian website
  - 320ms – Aircraft -> geo-synchronous satellite -> ground East Asia
  - 40ms – within Asia
  - 380ms Total

Prefix Transition in Action

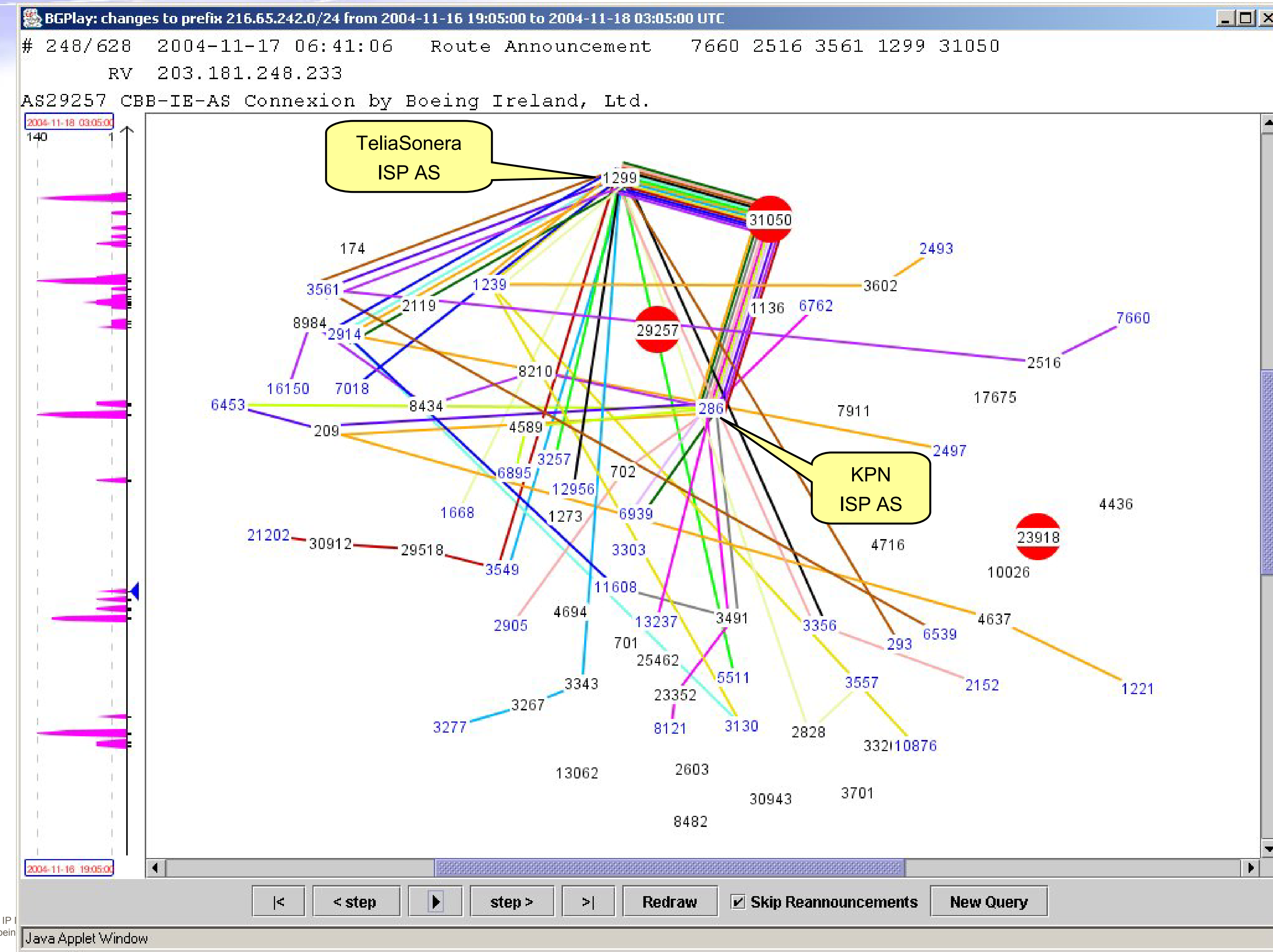


- An actual Lufthansa flight from East-Asia to Europe
  - November 17, 2004 01:00 -> 19:00 UTC
- BGP update collectors located throughout the globe collected mobile platform BGP updates as seen from their point of view
- This shows the transition process from one ground station to another
  - Each number 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 and BGPlay by Roma Tre University
  - http://www.routeviews.org/

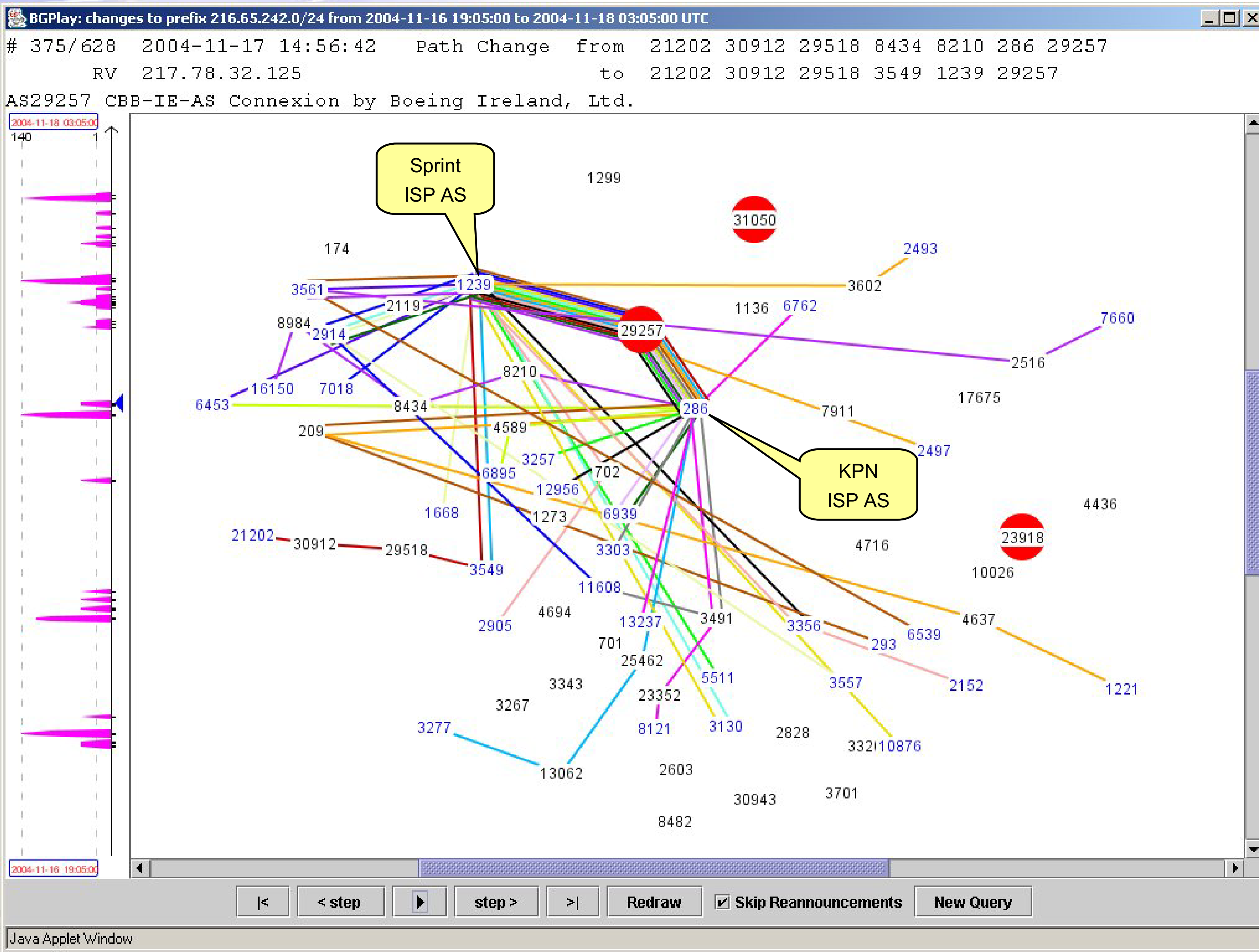
Routes Announced from Ibaraki, Japan



Routes Announced from Moscow, Russia



Routes Announced from Leuk, Switzerland



Challenges using BGP for Mobility

- /24 network propagation
  - 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 our service providers
- Prefix churn
  - Route changes occur a couple of times a day for intercontinental platforms
  - As a percentage of total global route-updates our updates are small
- Prefixes may have an “inconsistent” origin ASN
  - Current announcements originate at the active ground station
  - Changes when platform changes ground stations, but does not originate from two places at once
  - Scheme could be modified to originate from a “global mobile ASN”

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Route Flapping and Dampening

Will our routes be dampened by some providers?

- Testing and operational experience has shown that a single route update is unlikely to cause a route to be dampened by core networks. We see some dampening in specific edge networks after approximately 5 changes within a short period of time. In general, dampening for global network operators is 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 update

Future Prefix Management

- Address space Regionalization
  – 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

- 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

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Controlling Prefix Propagation

- We realize that as the number of mobile platforms increase the number of BGP announcements will also increase, perhaps causing concern in the future
- We have considered other mobility options and will continue to evaluate other options
- A “mobile prefix” BGP marker maybe desirable
  - A defined & recognized BGP community
    - such as NO_EXPORT defined in RFC 1997
  - Pros:
    - Allows each ASN to easily pass or filter mobile platform routes based on their policies, aggregates would not be marked
    - Could also be used to mark “traffic engineering” prefixes in the table today
  - Cons:
    - Communities are not transitive
  - This type of marker could also possibly be used for other “traffic engineering” prefixes

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Conclusions
BGP as a Mobility Solution

- ☑ Does not require special IP stacks on customer hosts
- ☑ VPNs and other long-term TCP sessions remain established through a ground station handoff
- ☑ 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

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Thank you
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