

Revisiting AS-ranking

Mickael MEULLE France Telecom Division R&D

June 2007



Agenda

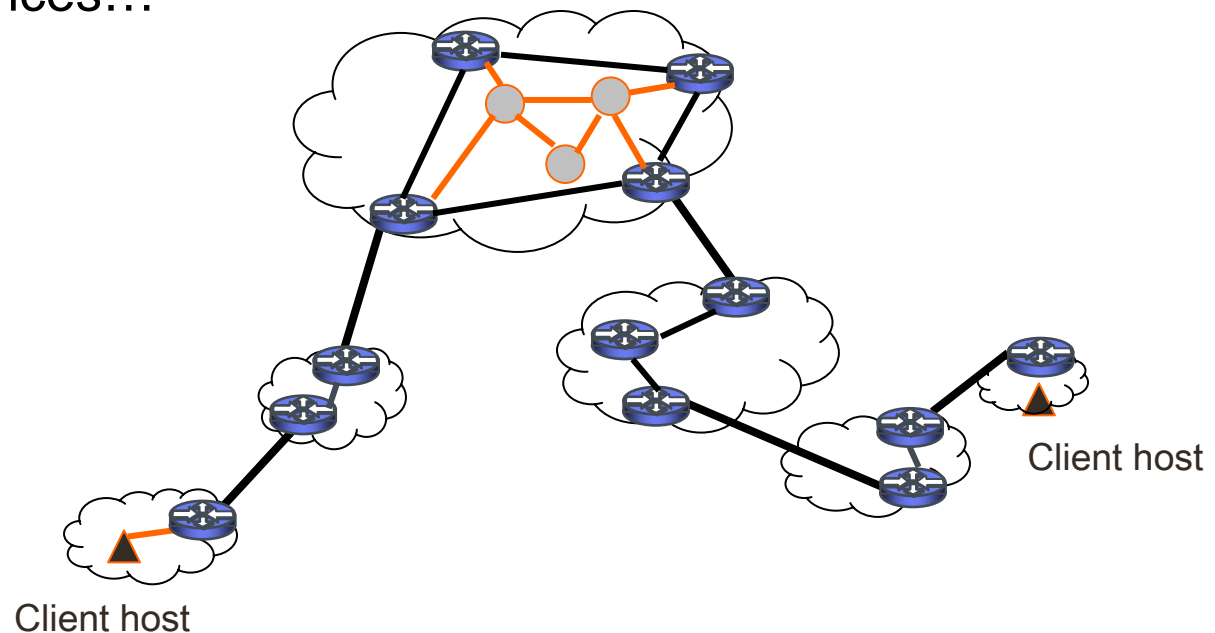
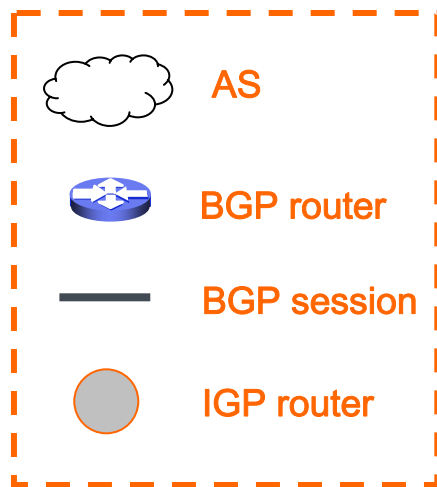
- Interdomain reachability with BGP
- Why studying AS ranking?
- A new approach to rank transit ASs
- Classification overview

Internet routing with BGP

- The Internet network is:
 - > More than 20 000 interconnected Autonomous Systems (ASs)
 - **stub** Networks (clients): ASs only send and receive traffic for themselves
 - Internet Service Providers (ISPs): ASs provide **transit** to other ASs
 - > A partition of the public IP address space into ranges (**prefixes**)
 - companies, DSL users, universities, administrations...
 - web farms, "Content Delivery Networks", hosting services ...
- Internet routing is handled by Border Gateway Protocol
 - > BGP routers propagate reachability of prefixes
 - > BGP routers maintain routing tables toward approximately 200 000 prefixes
- Internet connectivity
 - > each router know a route toward any public IP address

End-to-end Internet routes

- Internet paths between hosts rely on:
 - > BGP routes selected and propagated by BGP routers
 - > Router paths inside an AS are matter of the AS's internal routing
- BGP route selection and propagation rely on:
 - > Network topology: AS-level and router-level topologies
 - > Routing Policies of ASs: prefix announcements, route filters, route preferences...



Internet is a huge business place

- business agreements are negotiated for AS links

- > **Customer/Provider: C2P/P2C**

- Client pays provider for incoming and outgoing traffic
 - Client routers send to provider routers own & clients BGP routes
 - Provider routers send to client routers all their BGP routes

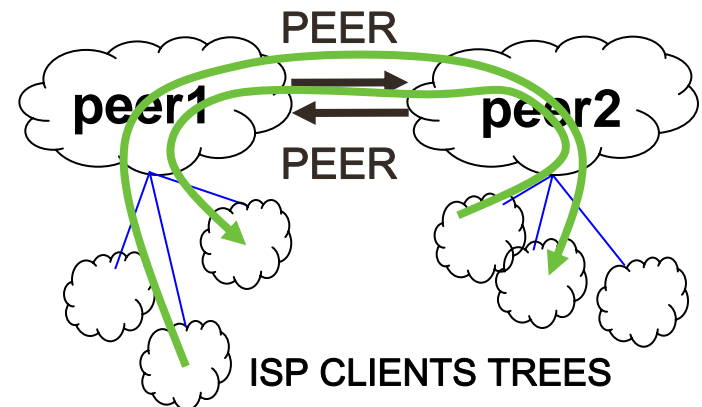
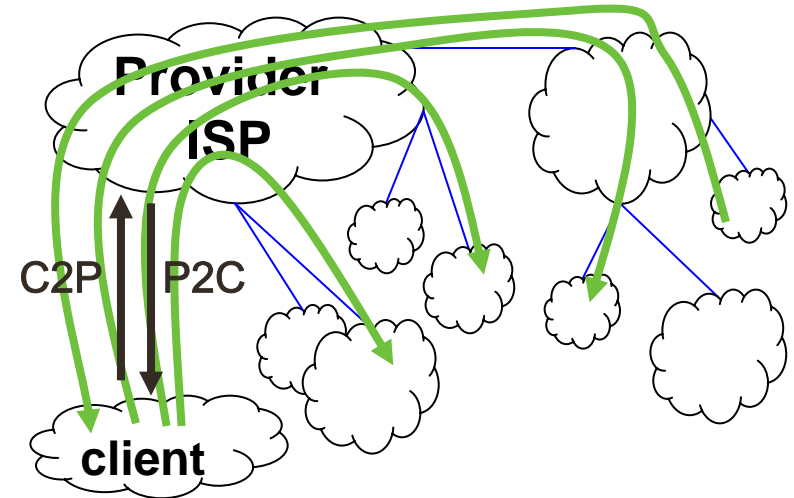
- > **Peering (“Sender Keep All”): PEER**

No money, no guaranty (no SLA)

- Transit only between clients of clients
 - on peering sessions, routers send own & clients BGP routes

- > **Others (closer to reality):**

- Regional / national transit & peering
 - IP prefix-based
 - Sibling SIB (same administration)

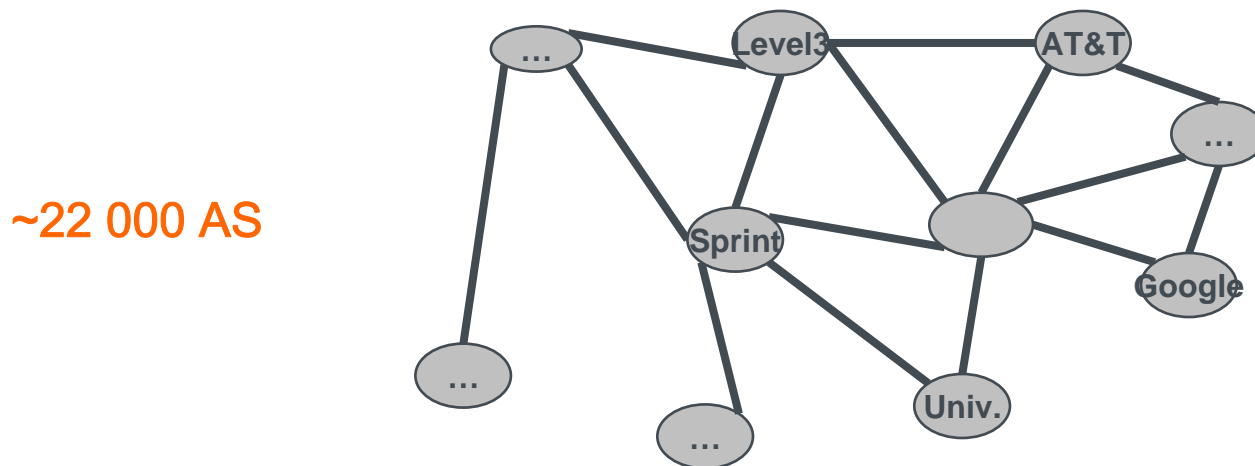


Decision support for AS interconnections

- The Reachability of an AS: BGP paths to prefixes
 - > Depends on many 'unknown' factors
 - > Business agreements, Traffic Engineering...
- A given reachability implies an underlying quality for IP packet forwarding
 - > business agreements and neighbors AS shape possible AS-level paths from a given AS
- Accurate negotiation of new inter-AS links:
 - > Needs knowledge about reachable prefixes and routes provided
 - Which prefixes? Are they cheaper for example?
 - Which hosts belonging to prefixes? Internet clients, provided contents...
 - What kind of BGP paths toward prefixes?
- **prefix and paths are unknown, real impact of a new link also!**

AS rankings: motivations

- AS rankings: a way to compare transit ASs
 - > Hierarchical position (economic)
 - > Topological position (connectivity)
- Reachability of an AS is strongly correlated with its position in the Internet Hierarchy
 - > Customer-to-provider & provider-to-customer agreements create hierarchy



AS rankings overview

- Approaches are mainly based on "BGP tomography"
 - Input: BGP tables at multiple vantage points → (AS_PATH, prefix)
 - Output: estimation about AS position in Internet hierarchy
- In state of the art: no universal ranking adopted
 - > "Black boxes"
 - Netconfigs: <http://www.netconfigs.com/general/ranks.htm>
 - FixedOrbit: <http://www.fixedorbit.com/metrics.htm>
 - Renesys: http://www.renesys.com/products_services/market_intel/rankings/
 - > Heuristics for Internet hierarchy:
 - Gao et al., "[On the Hierarchical Structure of the Logical Internet Graph](#)"
 - Subramanian et al., "[Characterizing the Internet Hierarchy from Multiple Vantage Points](#)"
 - > Caida AS rankings: http://www.caida.org/analysis/topology/rank_as/
 - Gaol: compute size of customer cones for each AS
 - Method: use AS-level graph annotated with inferred business agreements
 - > Linear algebra approach
 - Clerot et al., "[A Social Network Approach for the Ranking of the Autonomous Systems of the Internet](#)"
 - Wang et al., "[Inter-Domain Access Volume Model: Ranking Autonomous Systems](#)"

Issues in the estimation of AS ranks

- Graph-based metrics are not taking care of routing policies
 - > Topology considerations are erroneous because BGP paths are not shortest paths!
 - > Examples: betweenness centrality, triangles, clustering coefficient...
- Lacks of BGP tomography to accurately estimate *reachability* from all AS to all prefixes
 - > A small number of measurement AS
 - bias in data: prefixes seen and where, AS links seen....
 - > If all data is merged from all collectors
 - Some indicators can be over-estimated
- Uncertainty of inferred business relationship to identify customers
 - > degenerated problem: multiple solutions exist
 - > Model of agreements is too coarse

Mining BGP tomography for Transit

- We still use BGP feeds from Route-Views, RIPE and looking glass routers: more than 100 ASs with full BGP tables

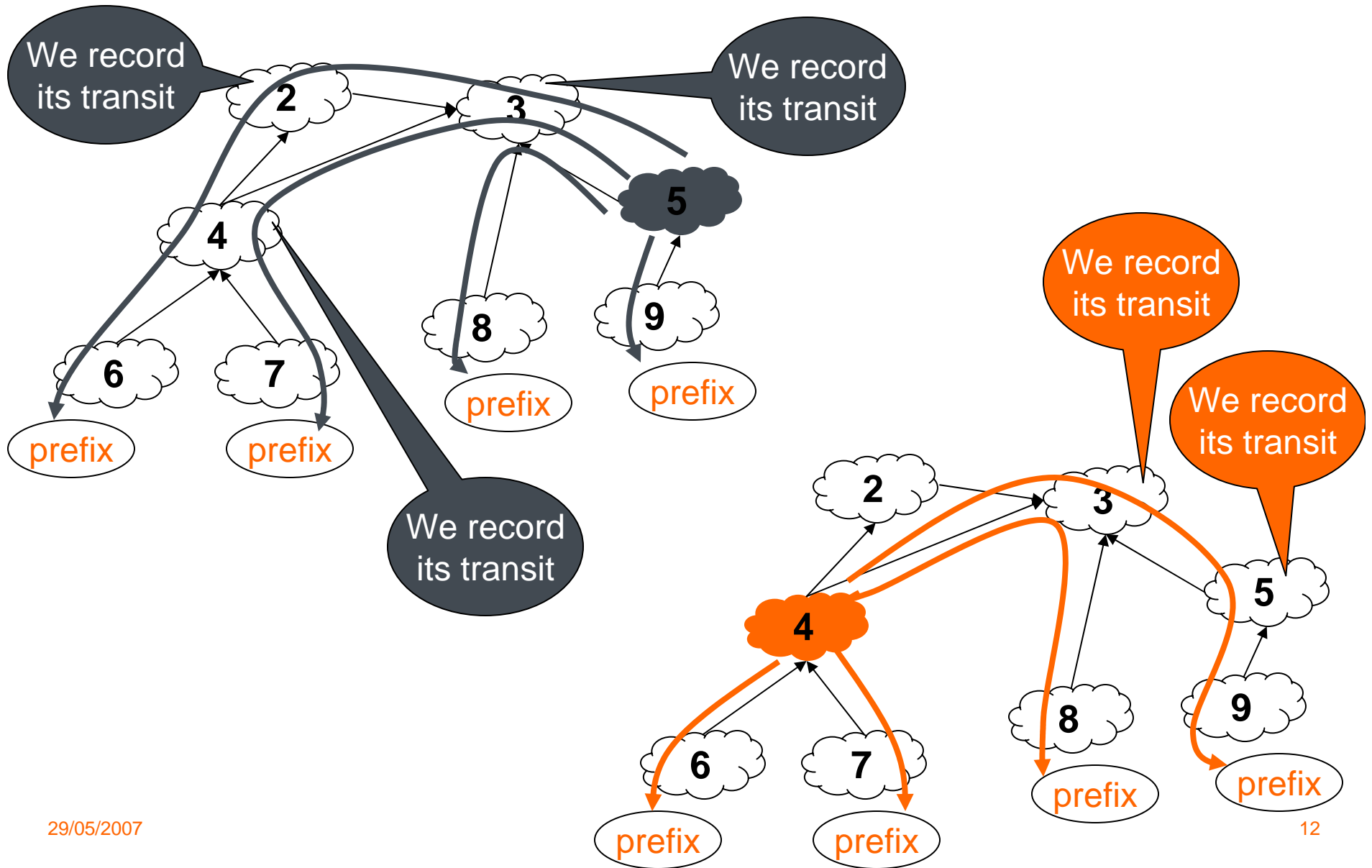
- How to mind BGP tomography for AS ranking computation?
 - > Goal is to estimate amount of customer prefixes provided by each AS
 - without relying on a model of business agreements...
 - without bias introduced by measurement points...
 - With freedom on the way to give importance to prefixes
 - > Keep in mind bias in estimation of amount of prefix observed
 - For ASs (limited view of measurement points)
 - On AS links (measurement point location)

- We search for the amount of IP space “behind” an AS
 - > End-to-end reachability is maintained:
 - Transit provider are responsible for propagation of reachability announces
 - Transit providers are observed on paths to customer prefixes

IP space transited by an AS

- IP Space transited by an AS as seen in a path at an observation point
 - > For a path (X-Y-Z-T) to prefix p, we record:
 - transit (X,Y,Z) of prefix p for Y
 - transit (Y,Z,T) of prefix p for Z
- Given a set of AS paths, we can compute:
 - > Set of prefixes transited by each AS X
 - Prefixes on sub AS paths of length 3 (*,X,*)
- Rank of an AS is the percentage of IP space transited
 - > This rank can be a weighted sum of each prefix importance
- We compute a rank for each AS, from each measurement AS (set of paths is split)
 - > We use only measurement AS with full routing tables
- AS ranking: average rank = average IP space transited

Average IP space transited



Advantages of this ranking

- Intuitively
 - > Any AS « far » from a measurement AS is seen to transit its customer prefixes
 - > Any AS « close » to a measurement AS has an over-estimated number of prefixes transited
- narrowed bias due to placement of measurement ASs
 - > If some ASs are providers of one or several measurement AS, it will not change so far the results
- Prefix granularity limits errors due to pure graph-based estimation of connectivity
 - > example: transit of some prefixes between two Tiers1 AS is not mis-understood!
- Compute the average IP space transited by an AS as seen from many measurement
 - > The sample of hundreds measurement AS (Route-Views and RIPE neighbors) becomes representative for the quantity measured

Results overview

- Sample taken in March 15th, 2007: 109 measurement ASs

- 1. [3356] LEVEL3 (14.388)
- 2. [1239] SPRINTLINK (11.460)
- 3. [1299] TELIANET (10.480)
- 4. [3549] GBLX (9.480)
- 5. [174] PSINET (8.023)
- 6. [2914] VERIO (7.767)
- 7. [209] ASN-QWEST (7.522)
- 8. [7018] ATT-INTERNET4 (5.610)
- 9. [701] ALTERNET-AS (5.489)
- 10. [3561] CWUSA (3.064)
- 11. [3257] TISCALI-BACKBONE (2.954)
- 12. [6461] ABOVENET (2.876)
- 13. [5511] OPENTRANSIT (2.839)

Results overview

- 14. [2516] KDDI (2.767)
- 15. [6453] TELEGLOBE-AS (2.701)
- 16. [4637] REACH (2.457)
- 17. [1273] ECRC (2.405)
- 18. [3320] UNSPECIFIED (2.364)
- 19. [3491] CAIS-ASN (2.061)
- 20. [8928] INTERROUTE (1.701)
- 21. [2497] IIJ (1.666)
- 22. [721] DLA-ASNBLOCK-AS (1.557)
- 23. [5400] CIPCORE (1.518)
- 24. [20965] GEANT (1.471)
- 25. [702] AS702 (1.319)
- 26. [286] UNSPECIFIED (1.280)

Conclusion

- We introduce a new AS ranking algorithm
 - > Use BGP tomography with public BGP feeds
 - Route-Views & RIPE projects + looking glass
 - > It records « foreign » transit of prefixes by ASs
 - > The value computed can be directly interpreted

- Advantages compared to state-of-art methods
 - > It is not a « black box »
 - > Take care of measurement bias
 - Over-estimated reachability of some ASs is averaged
 - > Take advantages of multiple routing tables used
 - The more tables as input, the more precise is result
 - > One can give more importance to some prefixes or restrict the set of prefixes for which ranking is computed

Thanks!