GreenTouch Services, Applications, and Trends Committee: Work Plan Update

GT SAT Committee (Steven K. Korotky, Chair)

GT Members' Meeting - Seattle

17 November 2011

GreenTouch Services, Applications & Trends Committee

Rationale: Network efficiency depends upon network architecture and technology, which depends upon services, applications, and traffic

Responsibility - Provides SA&T input to the GT Network Committee

Objectives:

- Collect data on current trends /validate baseline model
  - traffic, services and applications, etc.
- Identify present and anticipated services & applications
  - determine characteristics and requirements of S&A
    - e.g. bandwidth, latency, storage, spatial variation, temporal variation
  - work with Net Comm to align S&A with architectures
- Develop traffic trends/projections/forecasts
- Define methodologies
- Consider alternative metrics
  - e.g. carbon footprint, power per user, lifecycle analysis, total cost
- Formulate and execute projects within scope
- Document and socialize recommendations

GT SAT Committee: Activities Update (1/2)

- **Membership**
  - 44: 28 Contributors, 16 Observers, 25 Organizations
    - [9 Institutes, 7 Universities, 9 Industrial (6 Network Operators, 3 Suppliers)]
- **Tasks**
  - Service and Application Definitions and Traffic Trends for Baseline Architecture
- **Launch-to-Date Activities - Year 1**
  - GT SAT Committee Launch, GT-London (6/2010)
  - Traffic and Architecture Documents Review, GT-Amsterdam (11/2010)
  - Comments & Recommendations to Strawman Architecture (2/2011)
  - Network Operator Traffic Survey Recommendation (3/2011)
  - Definition and Characteristics of Applications Recommendation (4/2011)
  - First GT SAT Project Proposal (Telecomm Energy Audits) (4/2011)
- **Launch-to-Date Activities - Year 2 YTD**
  - Post-Seoul – next slide

GT SAT Committee: Activities Update (2/2)

- **Launch-to Date-Activities - Year 2 YTD (i.e. since GT-Seoul)**
  - Launch Mobile Traffic Study Group (5/2011)
  - Socialization of Recommendations for Feedback (4-11/2011)
  - Draft Application Taxonomy Document (11/2011)
  - Draft Macro Traffic Trends Document (11/2011)
  - Draft Contribution to Baseline Architecture Document (11/2011)
  - Delivery of traffic trend inputs to GT SEASON Project (11/2011)
  - Approval of first project proposal (Telecomm Energy Audits) (11/2011)

- **Next Activities – Year 2 (Going out of GT-Seattle)**
  - Finalize, approve and issue contribution to Baseline Architecture document
  - Work with Network Committee WG's to transfer Baseline Architecture recommendations and data
  - Formulate and execute plan to implement Traffic Survey
  - Formulate and execute plan to implement project proposal
  - Follow-up on new project proposal(s) and possible cross-organizational collaborations

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1. Macro Traffic Trends

Reference traffic projections for 2010-2020 by application and geographic region

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GT SAT Committee:
Macro Traffic Trend Methodology

- SAT Committee has carried out document reviews of strawman architecture, white paper, and reference documents relevant to traffic trends
  - "Baseline architecture planning document," Sec. 3 & 9, GT.
  - "Network infrastructure architectures …," Sec. 1-4, GT.
  - "Power trends in communication networks," Kilper *et al.*, JSTQE.
  - "Cisco visual networking index: forecast and methodology …," Cisco.
  - "Comments on network infrastructure architectures …," GT R&S WG.

- SAT Committee has prepared contribution to the Baseline Architecture Document including traffic projection tables
  - "GreenTouch Baseline Architecture – Section 3: Application Characteristics, Requirements, and Traffic," GT SAT Comm.
  - "GreenTouch SAT Traffic Projections 2010-2020," GT SAT Comm.
  - "GreenTouch SAT Application Taxonomy," GT SAT App. Tax. SG.

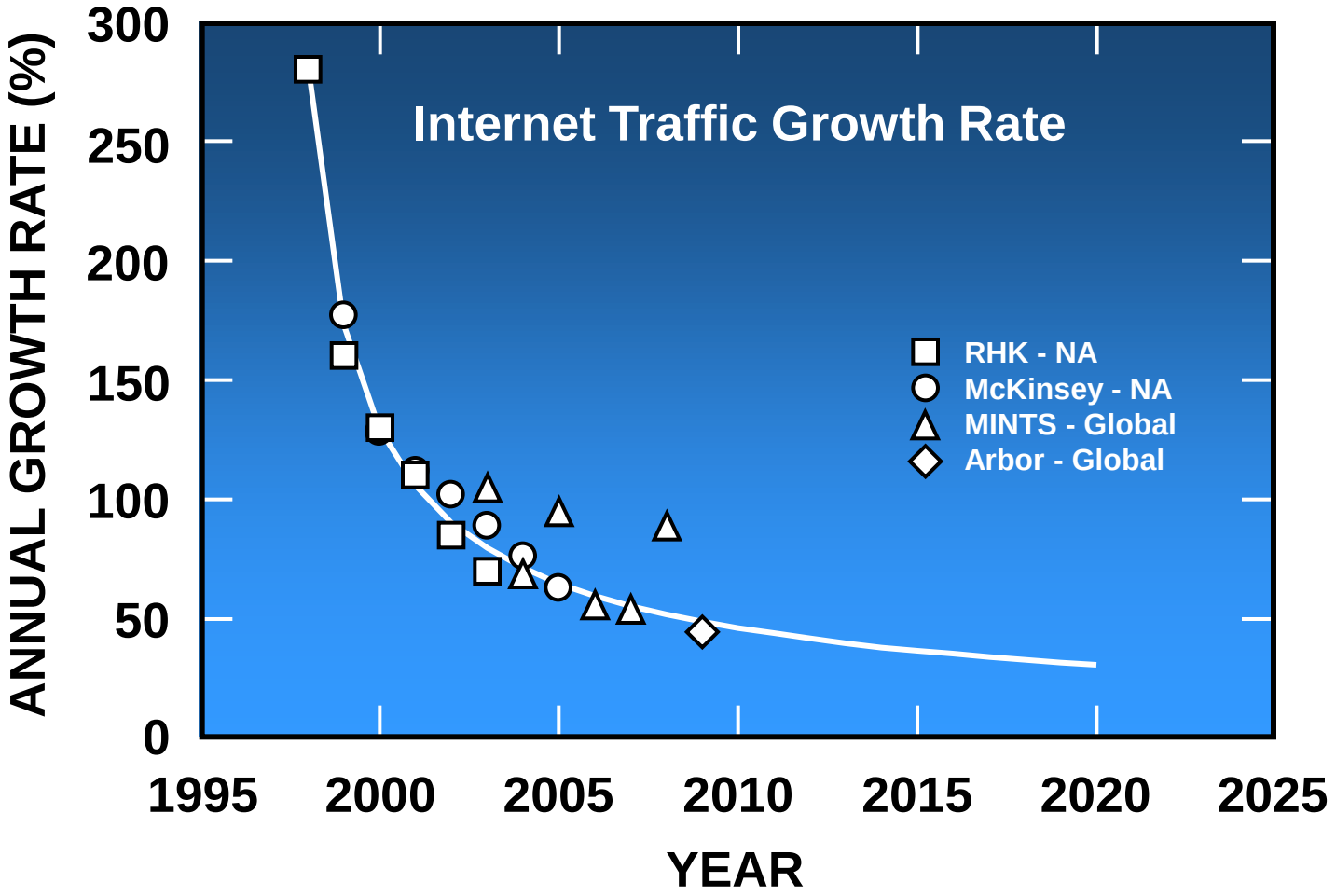
GT SAT Committee:
Macro Traffic Trends – Recommendation Highlights

Considering the large uncertainties inherent in all traffic projections and forecasts, the SAT Committee:

- … Recommends using regression projections (low, medium, high) of Cisco forecasts until such time as newer data is available.
- … Proposes that GT network solutions should be tested against a range of traffic trends, e.g. low (conservative), medium (most likely), and high (aggressive).
- … Recommends that when possible the most likely projections should be based on direct empirical (e.g. first hand historical) traffic data.
- … Plans survey of network operators' traffic (and other network characteristics and requirements) using a multiple-choice questionnaire.

Past and Anticipated Internet Growth

GT SAT Traffic Trends are based on regression analysis of CAGR



Trend and Projections: Kilper, Atkinson, Korotky, Goyal, Vetter, Suvakovic, and Blume, *JSTQE*, 2011.
Traffic Sources: RHK, 2004; McKinsey, JPMorgan, AT&T, 2001; MINTS, 2009; Arbor, 2009; AT&T 2008; VZ, 2008.

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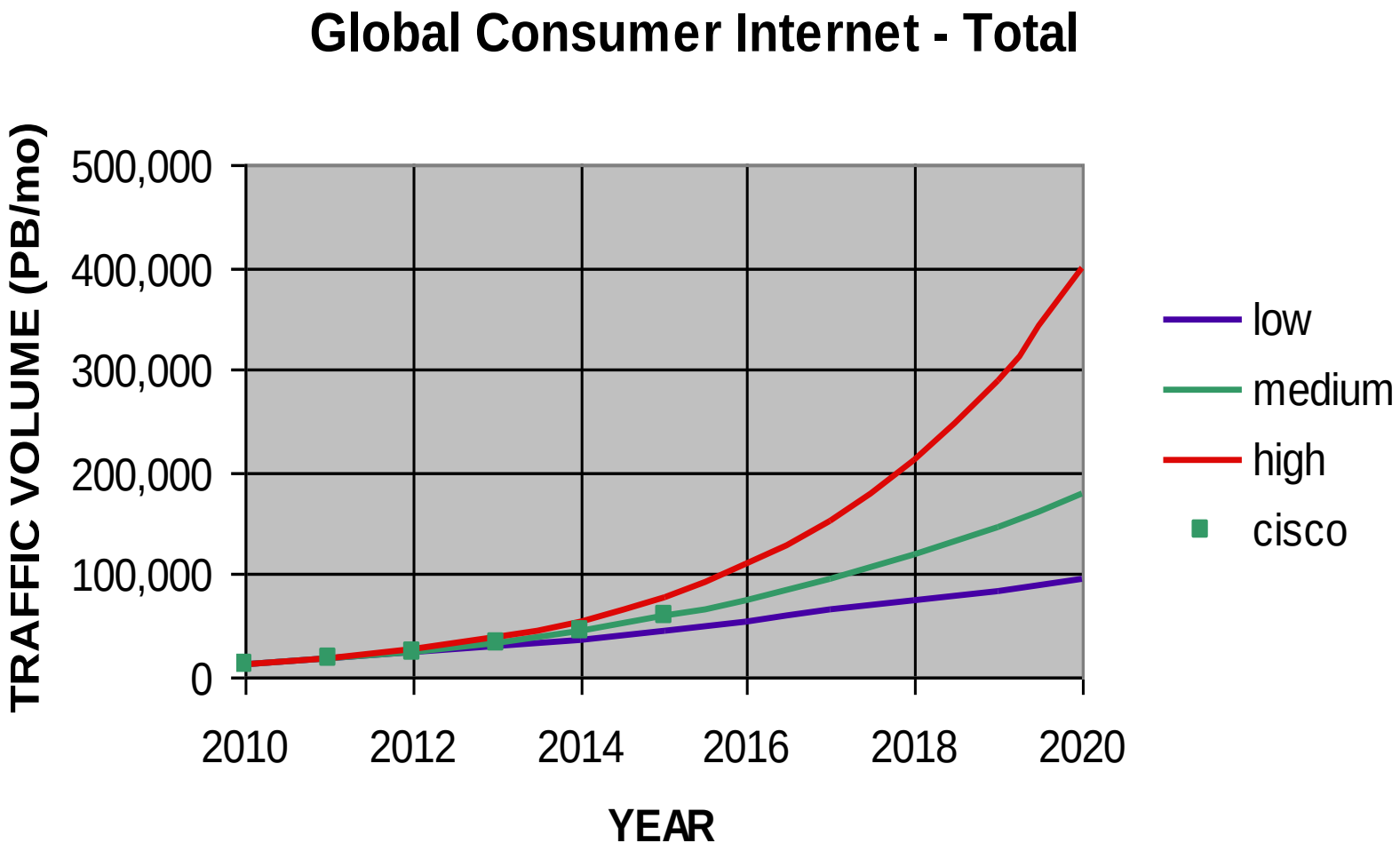
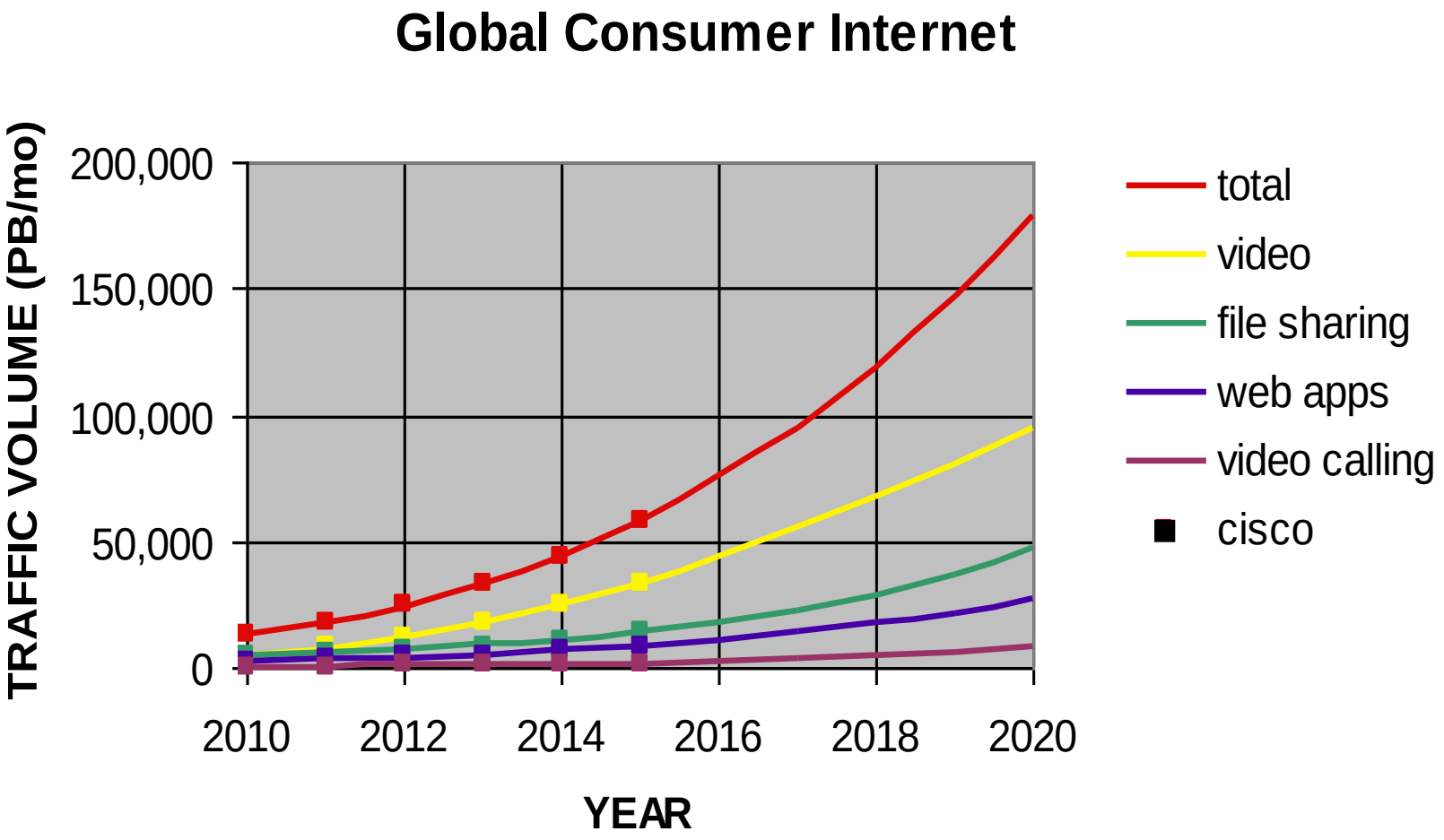
Traffic 2010-2020: Sample Projections



Traffic 2010-2020: Sample Projections



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2. Network Operator Survey:

A questionnaire on network traffic to validate projections

GT SAT Committee – Traffic Survey Study Group
Ed Chen, Chih-Ming Chen, Hiroyuki Kitada, Steve Korotky, Jaebong Lee

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Network Operator Survey

- Draft survey has been prepared and distributed for review
- Categories covered:
  - Company Profile - Customers, Networks, Services
  - Network and Traffic Profile - Geography, Demographics, and Services
  - Traffic Profile - Service/Application Mix
  - Traffic Profile - Load Variation
  - Traffic Volume
  - Traffic Growth
  - Energy Consumption
  - Router Packet Buffers

Network Operator Survey - Examples

- **Sample (from Traffic Volume section)**

D.1. What is the total current monthly traffic volume (petabytes per month, PB/mo)?

___ 0-50 ___ 50-100 ___ 100-200 ___ 200-500
___ 500-1000 ___ 1000-2000 ___ 2000-5000 ___ 5000-10000

D.2. What is the monthly traffic volume over the backbone (petabytes per month, PB/mo)?

___ 0-50 ___ 50-100 ___ 100-200 ___ 200-500
___ 500-1000 ___ 1000-2000 ___ 2000-5000 ___ 5000-10000

D.3. What is the monthly volume of mobile traffic (petabytes per month, PB/mo)?

___ 0-50 ___ 50-100 ___ 100-200 ___ 200-500
___ 500-1000 ___ 1000-2000 ___ 2000-5000 ___ 5000-10000

D.4. In your estimation, what percentage of mobile traffic will be off-loaded to WiFi and/or microcell in the coming 5 - 10 years (%)?

___ 0-20 ___ 20-40 ___ 40-60 ___ 60-80 ___ 80-100

Traffic Survey - Next Steps

- **Finalizing the survey content**
  - Closing on content with the Network Committee WG's
  - Pruning the length of the survey
  - Consideration of a validation format rather than a survey format
  - Grouping of topics for easy of response

- **Logistics**

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3. Applications Taxonomy:

A comprehensive classification of applications by requirements

GT SAT Committee – Applications Taxonomy Study Group
Fabrizio Amarilli, Sungbong Chang, Steve Korotky, Klaus Satzke

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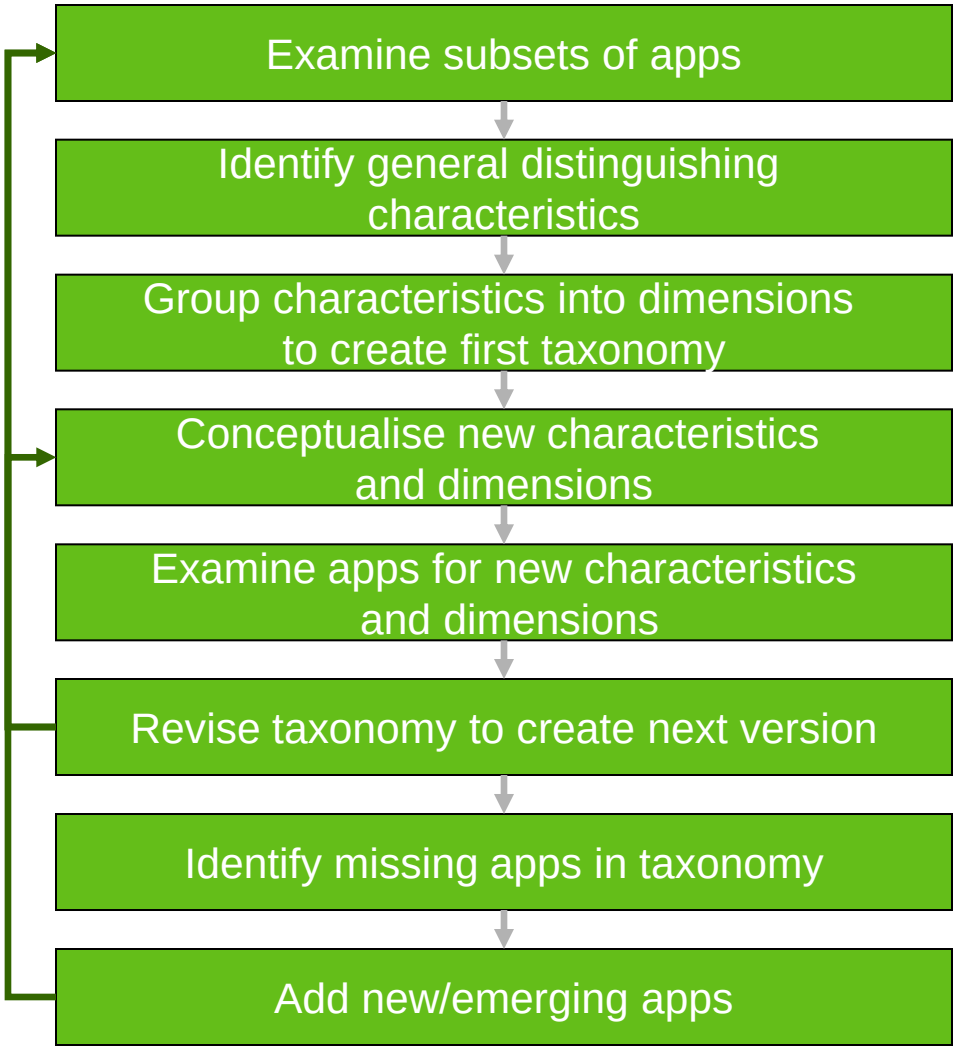
Application Taxonomy Development: An Iterative Process



Definitions of Application Categories

Cat. No.	Type	Description	Examples
1	**Video streaming**	1-way transport of A/V content for (semi-) professional use	HD/3D/VoD, Personal network-based content storage, IPTV, Internet Video (streaming video, video clip), Multi-view Video Distribution
2	**Conv. Video**	2-way transport of A/V content for conversation between humans	Video Conference, Interactive eLearning, Telecommuting, Telemedicine, Interactive/Multi-View Video Rendering, eHealth, Telepresence/Immersion, Realtime Entertainment, Immersive Environments
3	**Audio Streaming**	1-way transport of audio incl. HQ	e.g. Internet Radio
4	**Conv. Voice**	2-way transport of voice	VoIP
5	**Interactive messaging**	Messaging involving humans, sensors, machines	Data transport from critical supervisory systems: sensing, telematics, M2M systems
6	**Control traffic**	Exchange of status/ failure, signalling and network routing info	SIP Signaling
7	**General Data transfer**	General Data Transfer	File downloads, program updates, database use and back-up, scientific and computational cloud apps, transactional cloud services traffic, email, web services, P2P, web search...).

Adapted from ITU-T Recommendation Y.1541

QoS Requirements by Application Category

Application Category	Y.1541 QoS Class	Upper bound Packet Loss Rate	Upper bound transfer delay	Upper bound delay variation	Max. setup delay tol. (MSDT)	Typical BW need
1. Video streaming	6, 7	10^{-5} *)	100 ms	50 ms	SC-I	High (e.g. >250MB/s for HD VoD)
2. Conversational Video	0, 1	10^{-3}	100 ms	50 ms	SC-I	High (e.g. 3D video call: >375MB/s)
3. Audio Streaming	6, 7	10^{-5}	100 ms	50 ms	SC-I	Low - medium
4. Conversational Voice	0, 1	10^{-3}	<100 ms	< 30 ms	SC-I	Low
5. Interactive messaging	3, (2)	10^{-3}	100 ms	unspec.	SC-I to SC-II	Low
6. Control traffic	2	10^{-3}	100 ms	unspec.	SC-II	Low
7. General Data transfer	4, 6	10^{-3} - 10^{-5}	100ms	unspec.	SC-II to-SC-III	Low to high (>200Mb/s for telemedicine & network hosted apps)

Adapted from ITU-T Recommendation Y.1541

GreenTouch Baseline Architecture – Section 3 (p.1)

3 Application Characteristics, Requirements, and Traffic

GreenTouch Services, Applications, and Trends Committee
Authors: Fabrizio Amarilli, Sungbong Chang, Steven K. Korotky, and Klaus Satzke
Editors: Steven K. Korotky and Klaus Satzke

3.1 Introduction

GreenTouch works to identify technological and architectural solutions for future communication networks that can provide a substantial improvement in energy efficiency. The process of researching, developing, and designing solutions for this goal requires us to anticipate the needs of future communication networks – including the applications, traffic, and services to be supported, and the metrics by which they will be judged. This section of the GreenTouch Baseline Architecture document is intended to provide guidance on these requirements. In particular, the purpose of this section is to:

- Identify, characterize, and disseminate information on requirements of past, present, and anticipated applications in dimensions such as bandwidth, latency, storage, and their time- and spatial-dependence.
- Identify, analyze, and disseminate information on historical trends and current network traffic.
- Identify, formulate, and disseminate information on formulations, projections, and forecasts of future network traffic.
- Identify, define, and disseminate information on alternative metrics to judge network energy performance, such as carbon footprint, power per user, life-cycle resources, and cost.

Keywords: services, applications, application requirements, application taxonomy, bandwidth requirements, latency requirements, traffic, access traffic, mobile traffic, data traffic, video traffic, backbone traffic, traffic trends, traffic growth, traffic per subscriber, subscriber growth, traffic forecasts, traffic projections, traffic statistics, traffic profiles, traffic models, packet statistics, flow duration, traffic load variation, spatial traffic variation, temporal traffic variation, diurnal traffic cycles, peak traffic load, average traffic load, network performance metrics, constrained resources, energy consumption, energy efficiency, carbon footprint, life-cycle analyses, cost

3.2 Definitions

For the purposes of this document, this section contains working definitions of the terms: applications, services, and traffic.

GT SAT Committee: Next Steps

- **Issue Contribution to Baseline Architecture**
  - application taxonomy
  - macro traffic trends
  - work with Network Committee to transfer inputs, align and identify additional needs
- **Traffic Survey Logistics and Execution**
  - finalize
  - work out logistics
  - identify participants
  - execute plan
- **Telecommunication Energy Audit Project Launch**
  - finalize
  - work out logistics
  - identify participants
  - execute plan
- **New Project Proposals and Collaborations**
  - follow up

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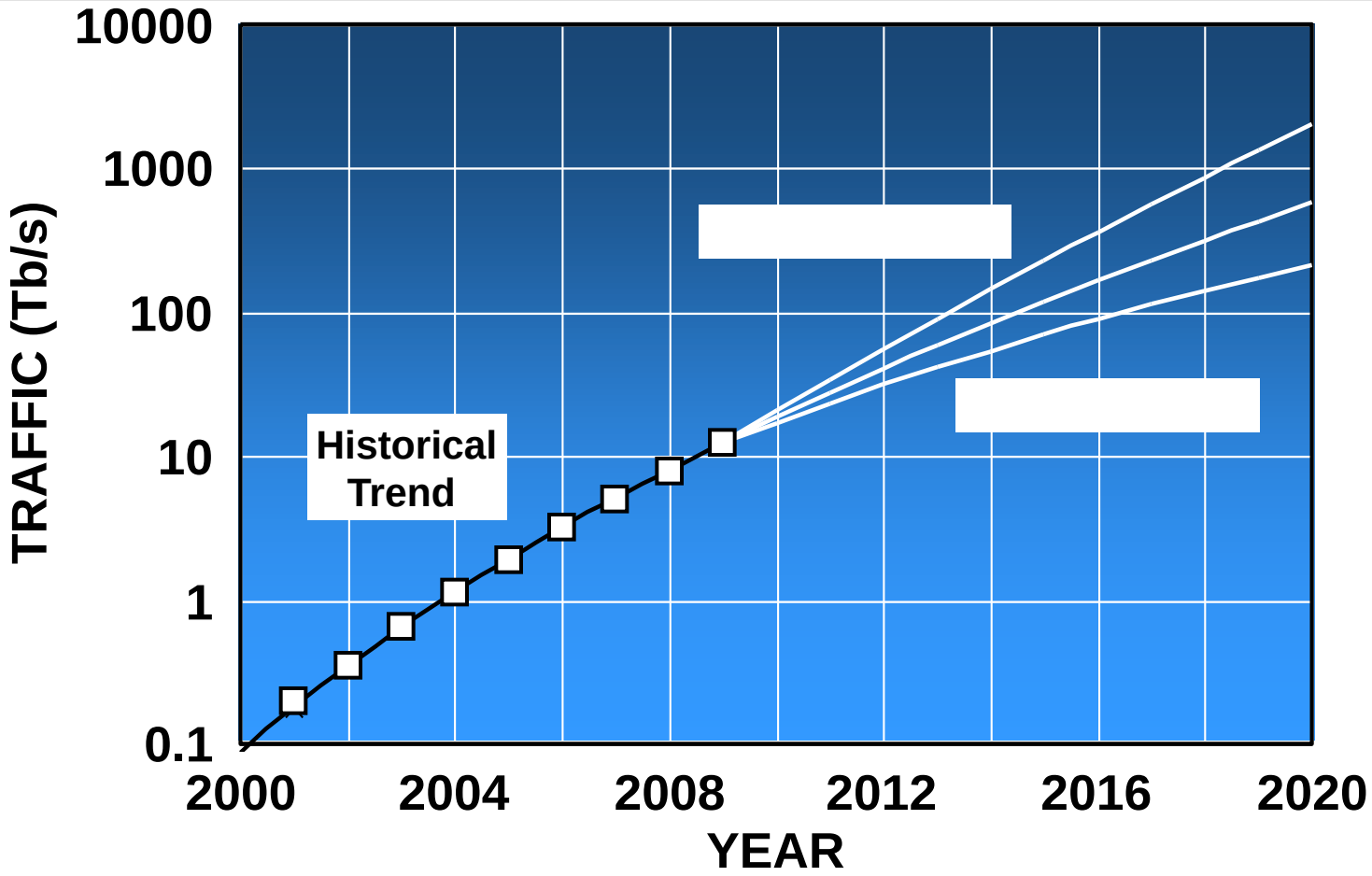
Backup Slides - Follow

Northern America Communication Backbone Traffic

Present compound annual growth rate is ~40%, or roughly 2X / 2 years



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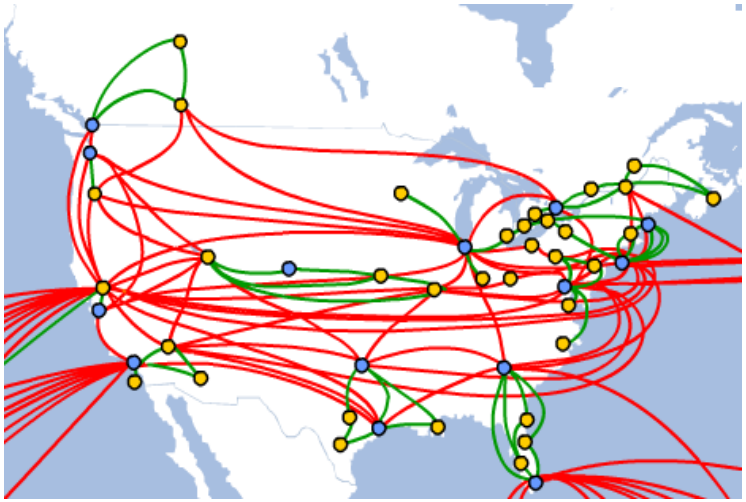
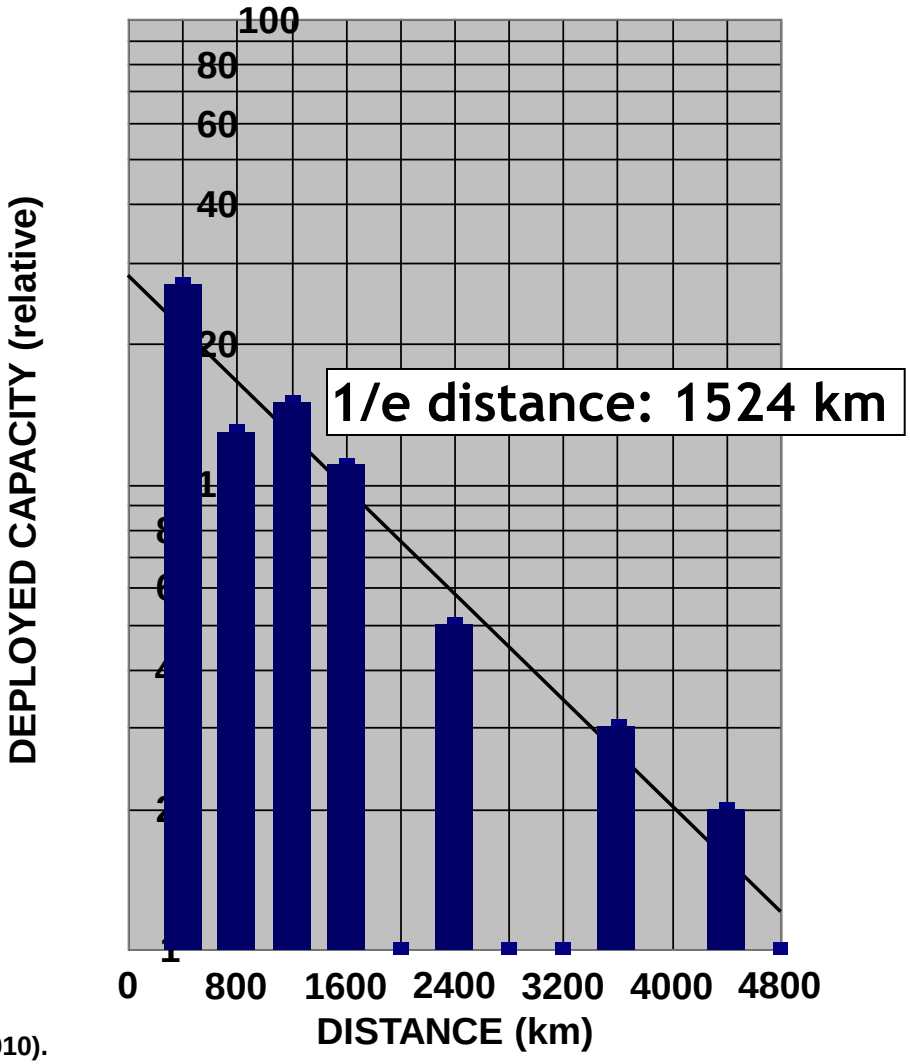
Empirical Distance-Dependence – An Example





Analysis: Korotky, Essiambre and Tkach, *BLTJ* 14(4), 285-295 (2010).
Network and Capacity Source: Verizon, 2008, http://www.verizonbusiness.com/us/about/network/#global .

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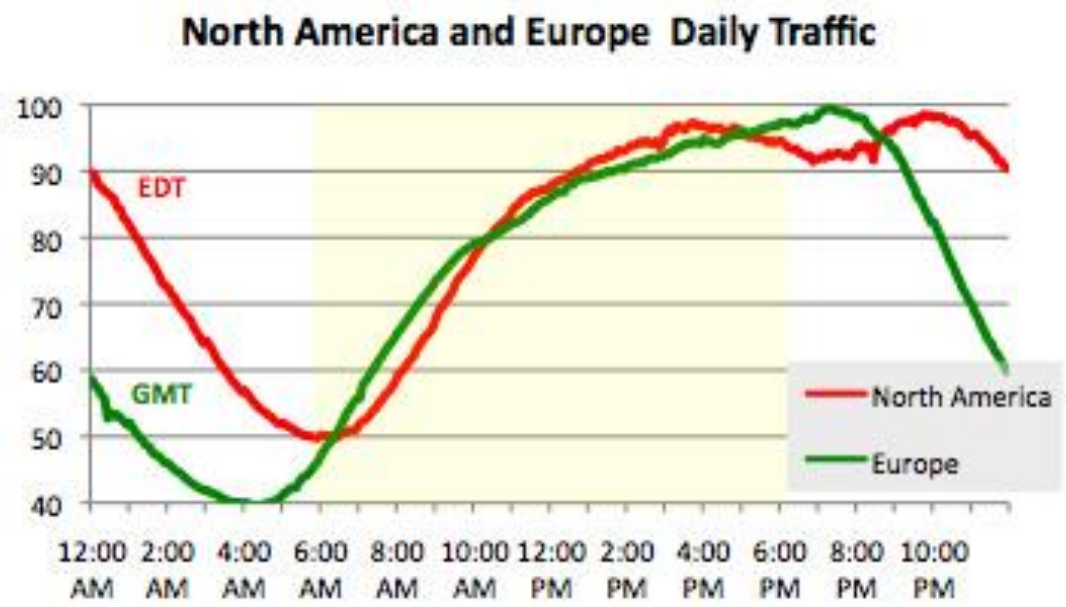
Temporal Variations – An Example



Labovitz, 2009.