TUBE

-- Pricing (Mobile Data) by Timing

Sangtae Ha, Soumya Sen, Carlee-Joe Wong, Uzair Aftab, Cagri Onuk, Mung Chiang

April 28, 2011
Use all the capacities, all the time

Software system computes and delivers the right pricing incentives so that wireless providers can manage congestion, reduce cost, monetize bandwidth assets
Wireless Internet Usage

Mobile data more than doubles each year

VolP traffic forecasted to be 0.4% of all mobile data traffic in 2015.
Source: Cisco VNI Mobile, 2011
Surge by Device

- Smartphone = x 24*
- Handheld Gaming Console = x 60*
- Tablet = x 122*
- Mobile Phone Projector = x 300*
- Laptop = x 515*

* Monthly basic mobile phone data traffic

Source: Cisco VNI Mobile, 2011
Ultra-Heavy Tail

ISP cost structure's fundamental problem

![Graph showing ISP's revenue and cost distribution over bandwidth consumption](image)
But Not Heavy All the Time...

How to leverage the peak-valley differential?
Time Elasticity: Our Survey

Many applications are time-elastic
Time Elasticity: Many Possibilities

- Streaming videos, Gaming
- Texting, Weather finance
- Email, Social Network updates
- Movies, book download
- Software Download
- File Backup
Policy Feasibility

FCC Dec. 2010 Statement
“...the importance of business innovation to promote network investment and efficient use of networks, including measures to match price to cost, such as usage-based pricing”
AT&T announces tethering details and new plans for iPhone, iPad

Changes to AT&T’s U.S. wireless data plans will affect how much iPhone and iPad users pay for mobile Internet access.

By Dan Frakes | Macworld

AT&T on Wednesday announced significant changes to the company’s U.S. wireless data plans that will affect how much iPhone and iPad users pay for mobile Internet access. The company also provided new details about iPhone data tethering for customers in the U.S.

According to AT&T’s press release, as of June 7, 2010, the current iPhone and iPad data plans — $30 per month for unlimited data on either the iPhone or iPad, or $15 for up to 250MB of data in a month for the iPad — are being replaced by two new plans that apply to both devices (as well as to other smartphones):

[ Stay up on tech news and reviews from your smartphone at infoworldmobile.com. | Get the best iPhone and iPad apps for pros with InfoWorld’s business iPhone and iPad apps finder. | See which smartphone is right for you in our mobile “deathmatch” calculator. ]

New data plans
DataPlus ($15 per month): Up to 200MB of data in a monthly billing cycle. According to AT&T, this plan is “designed for people who primarily like to surf the Web, send email, and use social networking apps.” If you exceed your 200MB limit during the billing cycle, you’ll be charged $15 for each additional 200MB of data.

DataPro ($25 per month): Up to 2GB of data in a monthly billing cycle. If you exceed your 2GB limit during the billing cycle, you’ll be charged $10 for each additional 1GB of data.

Each plan also includes unlimited access to AT&T Wi-Fi hot spots in the U.S. The new plans

Industry Moves: Large ISP

Usage Based Pricing:

AT&T Mobility: 2010.4
Verizon Wireless: 2011.2
AT&T: 2011.3
Industry Moves: Rural ISPs

“Customer do not want to any form of usage measurement or control under traditional definitions. We’d be very interested in seeing a pitch for time-dependent pricing.”

-- Delhi ISP, Upstate NY
Industry Moves: Wireless

Qualcomm’s interest in creating a scavenger class of service for CDMA networks
Industry Moves: India

- Telcordia launches Dynamic Pricing for Indian operators

- Uninor’s ‘Dynamic Pricing’ Tariff is no magic at all!

- Location Based Tariff Plan from Telenor in India
Dynamic Africa

African operators, which face many of the same difficulties as those in India, have devised some cost-lowering innovations of their own, such as dynamic tariffing, pioneered by MTN. This involves adjusting the cost of calls every hour, in each network cell, depending on the level of usage. Customers can check the discount they are
TDP: What is New

Opportunities & Challenges

Voice

Data (TUBE)

Time Dependent

Telcordia

India

Congestion Dependent

MTN

Africa

TDP

UAP
Can We Make Time Dependent Pricing Work for Mobile Data Traffic?

How to set the right prices?
How to integrate the whole feedback loop?
How to test for usability and scalability?
TUBE Technology and TDP & UAP Services
Time Dependent Pricing (TDP)

Large scale ISP cost optimization, taking user reaction into account
Proposition 1: The ISP’s optimization problem for time-varying rewards can be formulated as

\[
\min \sum_{i=1}^{n} p_i \left( \sum_{k=1, k \neq i}^{n} \sum_{j \in k} v_j w_j(p_i, i - k) \right) + f(x_i - A_i)
\]

(1)

subject to

\[
x_i = X_i - \sum_{j \in i} v_j \sum_{k=1, k \neq i}^{n} w_j(p_k, k - i) + \sum_{k=1, k \neq i}^{n} \sum_{j \in k} v_j w_j(p_i, i - k),
\]

(2)

var. \( p_i; i = 1, \ldots, n. \)
Estimating Waiting Function

Network Measurement → Price Determination → User Profiling → User Interface → User Response

- Economic modeling
- Waiting function
- Reward
- Delay
- Patience index

\[ w_{\beta_{ji}}(p, k - i) = C_{\beta_{ji}} \frac{p_i}{(k - i + 1)^{\beta_{ji}}} \]
TDP: Shoveling Peak to Valley

Traffic Volume in Each Period

- Without TDP
- With TDP

Traffic Volume (Mbps)

Hour
TDP: Architecture

User's iPhone iOS4

User GUI:
- Youtube
- Skype Call
- Yahoo Msng
- Safari Web
- Apple App Store

Price & Usage Database

Learning & Profiling Engine

Recommendation Engine

TUBE App Monitor

ISP Server

Price Information

Price optimizer

Waiting Function Estimator

Aggregate Traffic Measurement

App data

Allow or Block

TLS/SSL

User profile information is not exchanged. No unauthorized blocking of app data.
# TDP: Privacy and Security

<table>
<thead>
<tr>
<th></th>
<th>Privacy</th>
<th>Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Data</td>
<td>No DPI</td>
<td>Encrypted</td>
</tr>
<tr>
<td>User Profile Data</td>
<td>Not exchanged</td>
<td>Local authentication</td>
</tr>
<tr>
<td>Price Information</td>
<td>Public</td>
<td>TLS/SSL</td>
</tr>
<tr>
<td>Usage History</td>
<td>Private</td>
<td>TLS/SSL</td>
</tr>
<tr>
<td>Field Trials</td>
<td>Opt-in</td>
<td>IPSec VPN</td>
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</tbody>
</table>
Making 4G Achieve Target Rates

Multiplicative effect on interference mitigation to get advertised speed
Ultra Affordable Plan (UAP)

Scavenger class of users

UAP = Congestion-dependent pricing, fine timescale and autopilot
UAP: “Flashy Whitespace”

Wait for less congested (and lower priced) time

Exploit the leftover capacities, even in busy frequency during busy time
Bring Wireless to More People

Urban: everyone can have some type of access
## Impacts: Technological & Social

<table>
<thead>
<tr>
<th>Benefits to ISPs</th>
<th>Benefits to Consumers</th>
<th>Bridging the Digital divide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce cost</td>
<td>Reduce monthly charge</td>
<td>Ultra-affordable new service class</td>
</tr>
<tr>
<td>Manage congestion</td>
<td>Have choices when to use</td>
<td>Reduce middle mile capacity need</td>
</tr>
<tr>
<td>Monetize bandwidth</td>
<td>Auto-pilot</td>
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Towards Large-Scale Deployment

- **System Design & Algorithms**: 2/10-7/10: Completed
- **Prototype Development**: 7/10-4/11: Being Completed
- **Princeton Field Trials**: 5/11-7/11: In progress
- **TDP + UAP**: 7/11-1/12: In discussion
- **Reliance Customer Trial**: 7/11-1/12: In discussion
Princeton Trial: Money Flow

Real Money: $
Virtual Money: $

Corporate Plan Users

Wireless Provider

Rewards

TDP bills

Princeton Edge Lab

$100 + \sum_{1}^{3} \text{months} \left( \sum_{1}^{30} \text{days} \left( 1 - \frac{TDP_{peaks}}{TDP_{volume}} \right) \times \left[ \frac{TDP_{volume}}{TIP_{volume}} \right]^{1} \right) \times$1.67/day
Princeton Trial: Data Flow
Bridging the Theory-Practice Gap

* Easy to use GUI
* Customer care and privacy, constraint on DPI
* Custom-made package deals for each user
* Autopilot mode of operation
Bridging the Theory-Practice Gap

* System challenges:

  * Two user groups: Princeton Trial
  * iPhone users and iPad2 users
  * need for an interface between ISP and app developers
Pricing by Timing Benefits Everyone

Thank you