Secondary Markets for Mobile Data: Feasibility and Benefits of Traded Data Plans

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Mobile Data Usage

Mobile data traffic by application type (monthly ExaBytes)

Source: Ericsson Mobility Report June 2014.
Mobile Data Caps

2011  Verizon ends unlimited data plan

By Laurie Segall @CNNMoneyTech July 6, 2011: 9:45 AM ET

<table>
<thead>
<tr>
<th>Monthly fee</th>
<th>Verizon Old</th>
<th>Verizon New</th>
<th>AT&amp;T Old</th>
<th>AT&amp;T New</th>
<th>Sprint Old</th>
<th>Sprint New</th>
</tr>
</thead>
<tbody>
<tr>
<td>$110</td>
<td>12GB</td>
<td>15GB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$130</td>
<td>15GB</td>
<td>30GB</td>
<td>15GB</td>
<td>30GB</td>
<td>30GB</td>
<td>60GB</td>
</tr>
<tr>
<td>$150</td>
<td>20GB</td>
<td>40GB</td>
<td>20GB</td>
<td>40GB</td>
<td>40GB</td>
<td>80GB</td>
</tr>
<tr>
<td>$225</td>
<td>30GB</td>
<td>60GB</td>
<td>30GB</td>
<td>60GB</td>
<td>60GB</td>
<td>120GB</td>
</tr>
<tr>
<td>$300</td>
<td>40GB</td>
<td>80GB</td>
<td>40GB</td>
<td>80GB</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>$375</td>
<td>50GB</td>
<td>100GB</td>
<td>50GB</td>
<td>100GB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Monthly cost for data only portion of the various carrier's group/family plans. Individuals may do better with a single-line plan.

* Sprint offers higher tiers through its business program should you require them.
**Mobile Data Overages**

My monthly data: $298/6GB
Overage fee: $50/500MB
How could I afford the steep overage fees?
**Shared Data Plans in HK**

*Shared data plans* allow data caps to be shared across multiple users and devices; thus, heavy users can avoid overages by sharing the leftovers of lighter users.

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<table>
<thead>
<tr>
<th>Monthly Fee</th>
<th>Local Data</th>
<th>Thereafter Charge (on 'Advise and Consent' basis)</th>
<th>No. of SIMs</th>
<th>Voice Mins (Basic)</th>
<th>Contract Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>HK$438</td>
<td>6GB</td>
<td>HK$50/500MB</td>
<td>3 (1+2 SIMs)</td>
<td>4,000</td>
<td>24 months</td>
</tr>
<tr>
<td>HK$558</td>
<td>10GB</td>
<td>HK$50/500MB</td>
<td>3 (1+2 SIMs)</td>
<td>5,000</td>
<td>24 months</td>
</tr>
<tr>
<td>HK$798</td>
<td>20GB</td>
<td>HK$50/500MB</td>
<td>3 (1+2 SIMs)</td>
<td>5,000</td>
<td>24 months</td>
</tr>
</tbody>
</table>

The Account Owner is responsible for the specified service plan and has complete financial responsibility for the monthly bill of the specified service plan.
**Shared Data Plans in US**

**Plan pricing examples**

Please note that these Mobile Share Value plans do not include device costs.

<table>
<thead>
<tr>
<th>Families (4 smartphone lines)</th>
<th>AT&amp;T Next or NO Annual Contract option*</th>
<th>New 2-year contract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan Charge for 10GB</td>
<td>$100</td>
<td>$100</td>
</tr>
<tr>
<td>Smartphone access charge</td>
<td>$60 ($15 per line)</td>
<td>$160 ($40 per line)</td>
</tr>
<tr>
<td>Total per month</td>
<td>$160 <strong>Great value!</strong></td>
<td>$260</td>
</tr>
</tbody>
</table>

**Legend:**
- **At&t**
- **Verizon wireless**

**Line Access**

<table>
<thead>
<tr>
<th>Total Access</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4 Smartphones on MORE Everything</strong></td>
</tr>
<tr>
<td>4 x $40 monthly line access</td>
</tr>
<tr>
<td>8 GB $85 monthly account access</td>
</tr>
<tr>
<td>$245 monthly access*</td>
</tr>
</tbody>
</table>

**Data Access**

<table>
<thead>
<tr>
<th>Total Access</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4 Smartphones on MORE Everything with Edge</strong></td>
</tr>
<tr>
<td>4 x $15 monthly line access</td>
</tr>
<tr>
<td>8 GB $85 monthly account access</td>
</tr>
<tr>
<td>Save $100 $145 monthly access**</td>
</tr>
</tbody>
</table>
What if users could *BUY* data caps from *any* other users?
Users trade data on an ISP-mediated exchange platform, which creates the secondary market for mobile data.

- ISP charges the sellers an administration fee per unit data sold.
- The sellers can set their own price per unit between the administration fee and the overage fee.
- The buyers could then purchase additional data from sellers.
A Real-life Example
How do users decide their bids to buy or sell data?
SELLERS' OPTIMAL BIDS

The expected utility of the $j$th seller when selling $s_j$ data:

$$E(U_j^s | s_j) = \int_{d_j^s-o_j^s}^{d_j^s-s_j} V_j^s(c_j^s)f(c_j^s)dc_j^s + (\sigma_j - \rho)s_j$$
**Buyers' Optimal Bids**

The expected utility of the $l$th buyer when purchasing $b_l$ data:

$$E(U_l^b | b_l) = \int_{d_l^b - o_l^b}^{d_l^b + b_l} V_l^b(c_l^b)f(c_l^b)dc_l^b - b_l\pi_l$$
Can offering a traded data plan be profitable for ISPs?
ISP Matching

Optimization variable:
\[ \Omega = [\Omega_{lj}]_{l,j=1}^{L,J} \geq 0: \Omega_{lj} \text{ represents the percentage of the } l\text{th buyer's demand } b_l \text{ that is satisfied by the } j\text{th seller's data supply } s_j. \]
**Matching Constraints**

The buyer will buy at most $b_l$ amount of data:

$$B = \left\{ \Omega \left| \sum_{j=1}^{J} \Omega_{lj} \leq 1, \ l = 1, \ldots, L \right. \right\}$$
The amount of money paid by buyer $l$ must be higher than the offering of all sellers to this buyer:

$$\Pi = \left\{ \Omega \ \bigg| \sum_{j=1}^{J} \Omega_{lj} \sigma_j \leq \pi_l \sum_{j=1}^{J} \Omega_{lj}, \ l = 1, \ldots, L \right\}$$
The total amount of money paid by all buyers to seller $j$ must be higher than the offering of this seller:

$$
\Sigma = \left\{ \Omega \left| \sum_{l=1}^{L} \Omega_{lj} b_l \geq \sigma_j \sum_{l=1}^{L} \Omega_{lj} b_l, \; j = 1, \ldots, J \right. \right\}
$$
Matching Constraints

Seller $j$ will sell at most $s_j$ amount of data to all buyers:

$$\mathcal{S} = \left\{ \Omega \mid \sum_{l=1}^{L} \Omega_{lj} b_l \leq s_j, \quad j = 1, \ldots, J \right\}$$
**DIFFERENT TYPES OF REVENUE**

ISP matching objective:

\[
\omega \rho \sum_{j=1}^{J} \sum_{l=1}^{L} \Omega_{lj} b_l + (1 - \omega) \sum_{l=1}^{L} \sum_{j=1}^{J} (\Omega_{lj} b_l \pi_l - \Omega_{lj} b_l \sigma_j),
\]

where the parameter \( \omega \) trades off between administration revenue and bid revenue
Motivation

User Trading Behavior

ISP Trading Policies

Numerical Evaluation

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**ISP Revenue Maximization by a Linear Program**

maximize $\omega \rho \sum_{j=1}^{J} \sum_{l=1}^{L} \Omega_{lj} b_l$

$+ (1 - \omega) \sum_{l=1}^{L} \sum_{j=1}^{J} (\Omega_{lj} b_l \pi_l - \Omega_{lj} b_l \sigma_j)$

subject to $\Omega \in B \cap S \cap \Pi \cap \Sigma; \Omega \geq 0.$

variable: $\Omega.$
Matching Feasibility

If \( \pi_l < \sigma_j \) and

\[
\omega < \frac{\max_j \sigma_j - \min_l \pi_l}{\rho + (\max_j \sigma_j - \min_l \pi_l)},
\]

then the ISP will not match buyer \( l \) to seller \( j \).
Revenue Benefit

A necessary condition for the ISP to earn more revenue in the secondary market than in the primary market is

\[
\frac{p}{\rho} \leq \min_{l, \ldots, L} \frac{b^*_l(p)}{b^*_l(\rho)}.
\]
DATA TRADING DYNAMICS

ISP revenue maximization for matching sellers and buyers

Data trading between seller j and buyer l

Seller j

Seller bid

Matched seller data

Buyer l

Buyer bid

Matched buyer data

Matched seller data

Data trading between seller j and buyer l
DATA TRADING DYNAMICS

\[
\begin{align*}
\text{maximize} & \quad \omega \rho \sum_{j=1}^{J} \sum_{l=1}^{L} \Omega_{lj} b_l \\
& \quad + (1 - \omega) \sum_{l=1}^{L} \sum_{j=1}^{J} (\Omega_{lj} b_l \pi_l - \Omega_{lj} b_l \sigma_l) \\
\text{subject to} & \quad \Omega \in \mathcal{B} \cap \mathcal{S} \cap \mathcal{P} \cap \Sigma; \Omega \geq 0. \\
\text{variable:} & \quad \Omega.
\end{align*}
\]
**DATA TRADING DYNAMICS**

\[
\text{maximize} \quad \omega \rho \sum_{j=1}^{J} \sum_{l=1}^{L} \Omega_{lj} b_l \\
+ (1 - \omega) \sum_{l=1}^{L} \sum_{j=1}^{J} (\Omega_{lj} b_l \pi_l - \Omega_{lj} b_l \sigma_l) \\
\text{subject to} \quad \Omega \in B \cap S \cap \Pi \cap \Sigma; \quad \Omega \geq 0. \\
\text{variable:} \quad \Omega.
\]
**DATA TRADING DYNAMICS**

Motivation

User Trading Behavior

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Numerical Evaluation

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\[
\text{maximize} \quad \omega \rho \sum_{j=1}^{J} \sum_{l=1}^{L} \Omega_{lj} b_l
\]

\[
+ (1 - \omega) \sum_{l=1}^{L} \sum_{j=1}^{J} (\Omega_{lj} b_l \pi_l - \Omega_{lj} b_l \sigma_l)
\]

subject to

\[\Omega \in \mathcal{B} \cap \mathcal{S} \cap \mathcal{P} \cap \Sigma; \ \Omega \geq 0.\]

variable: \[\Omega.\]

---

\[
\sum_{l} \Omega_{lj}(k + 1) b_l(k) < s_j(k)
\]

\[
d_j^x(k + 1) \leftarrow d_j^x(k) - \sum_{l} \Omega_{lj}(k + 1) b_l(k)
\]

\[
o_j^x(k + 1) \leftarrow o_j^x(k) - \sum_{l} \Omega_{lj}(k + 1) b_l(k)
\]

---

\[
\sum_{j} b_l(k) \Omega_{lj}(k + 1) < b_l(k)
\]

\[
d_i^y(k + 1) \leftarrow d_i^y(k) + \sum_{j} b_l(k) \Omega_{lj}(k + 1)
\]

\[
o_i^y(k + 1) \leftarrow o_i^y(k) + \sum_{j} b_l(k) \Omega_{lj}(k + 1)
\]
The matching optimization always matches the sellers with lower prices and the buyers with higher prices first.
**Experiments with User Data**

The ISP usually but not always gains revenue in the secondary compared to the primary market.
Experiments with User Data

Buyers and sellers always increase their utilities in the secondary market.
The ISP and users can indeed all benefit from the secondary market trading.
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Thank you!

Q & A

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