“It all makes perfect sense
Expressed in dollars and cents”
References

Comer Ch 6
Clemm pp. 251-5

C. Metz: “AAA protocols: authentication, authorization, and accounting for the Internet”, IEEE Internet Computing

J. Liu et al: Introduction to Diameter

[Mkt] Market Clarity: Understanding the trans-Tasman broadband value gap: ISP costs in Australia and New Zealand

D. Ariely: Predictably Irrational, Harper Collins
Outline

Context
  FCAPS links
  Accounting in organisations
  Components of accounting

End-user accounting
  Plans and acquiring & keeping customers
  Tariffs

Access network accounting (AAA)

Service provider costs
**FCAPS links**

**Faults:** Little overlap.
- SLA [VZ] may offer compensation for service outages.
- Excess use due to malfunction may reflect in account.

**Configuration:**
- New customer needs new account & new service configuration.
- Rapid service config → rapid revenue from providing service.

**Security:** Authentication → Accounting → Authorization

=> AAA protocols, e.g. RADIUS/DIAMETER
- Fraudulent use (e.g. due to poor security) impedes accounting.
- Recording use (e.g. src/dst of traffic) used for both
  - Security: Identify attacker, track how they penetrated
  - Accounting: Metering & billing
Role of accounting in organisations

**Service providers** must generate revenue from providing service

**IT department of an enterprise** should
- measure cost effectiveness of technology to contain costs and justify not outsourcing
- apportion costs amongst departments; may not need to bill them
- verify ISP's charges

**Accounting management = collecting revenue (billing) & supporting functions,** e.g.
- metering use s.t. know who to bill & for what
- restricting access to only those who have credit
Components of accounting mgt

Accounting management consists of:

- **Metering**: Collecting accounting data to measure use
- **Setting tariff**: Defines fee structures
- **Billing**: Similar to billing in most businesses:
  - Issue bills, send reminders
  - Track customer data, e.g. contact address, credit

![Diagram of accounting management process](image)
Outline

Context

End-user accounting
- Plans and acquiring & keeping customers
  - Acquiring customers: Advertising
  - Phone charges
  - Flat-rate vs usage-based
  - Real-time vs offline accounting
- Retaining customers: Sticky services to reduce churn

Tariffs

Interacting with other service providers
Google search results for "wireless internet".
Advertisement charges:
- Traditionally by # of “impressions”
- Web: “Cost Per Click (CPC)”

Weighted CPCs:
- $2.02 including “mobile wireless”
- $3.86 excluding “mobile wireless”

Conversion rate may be 10% of click-through rate (hopefully higher)

Acquisition cost = $3/10% = $30

Amortize (spread out) over life of customer
Phone charges

Traditional landline:
• Flat-rate “line rental” charge + use-based billing (duration of call + distance) “in arrears”
• Party that initiates call gets billed (except 1800 numbers & reverse charges calls)

More recently:
• Prepaid calling
• Capped charges, irrespective of duration or even distance

Differences from “data networks”:
• Each call needs same service (can’t adjust service level)
• Identifiers (phone #s) suggest location=tariff cue
• End-users can measure usage (time); c.f. data vol.
Flat-rate & use-based billing

Flat-rate billing: User pays monthly service fee.
• Traditionally used for data networks because of enterprise/LAN origins, with limited accounting for use
• Particularly in US, as opposed to PTT-dominated Europe.

Use-based billing: User pays according to amount of service used
• ISPs shifting towards use-based billing because of few very heavy users (p2p/video).
• US ISPs introducing use-based charging circa 2010
Distribution of usage

Figure 4.2.2 Distribution of Usage in May 2002

Korea Telecom
Unlimited downloads
Lite: $25 for 4Mb/s
Premium: $33 for 13Mb/s

J. Min: "Cross-user subsidy in residential broadband service", MIT MSc thesis
Real-time (online) vs offline account processing

Usage-based bills sent in arrears (e.g. monthly) can be computed at “any time” (of day/week); “offline”

Real-time accounting is important for:

- **Prepaid services**: When call starts, need to immediately determine if caller has enough credit.

- **Flat-rate billing**: Maintain current record of usage so can throttle throughput when user reaches quota.
  - Throttling done by using traffic shapers/policers - TELE9751 shows how they are implemented
  - Same throttling/rate-limiting mechanisms used to support multiple tariffs & limit use after quota
Retaining customers

“Churn” = customer turnover
• Contracts (e.g. 12 or 24m)
  √ Amortize acquisition costs
  × Impede acquisition
• Might stay longer
  e.g. 4 years <L6]

Bundle “sticky features” (e.g. email, phone) to reduce churn

Bigpond features [http://go.bigpond.com/broadband/]
Outline

End-user accounting
Plans and acquiring & keeping customers

Tariffs
Vary prices (products) for different customers
Choice of price (product) for a customer
Anchors
Decoys
ARPU and the bottom line

**Revenue** = income from normal business activities 
ed.g. selling subscriptions to customers

**ARPU (Average Revenue Per User)**

= revenue / # subscribers (per month)

- Vendors promote features that might increase ARPU
- ARPU >= (profit = margin = return) = revenue - cost

**Average Margin Per User (AMPU)**

- More important, but used less ?!
- Margin readily determined when cost of goods approaches product price; c.f. capital-intensive telcos

**Best metric?:** Return On Investment (ROI) – risk

ROI = return/investment
Why have multiple tariffs?

A single tariff may not maximise revenue†:
• Too high for some potential customers
• Less than what some customers might have paid

=> Segregate the market with a range of tariffs
• according to service/use, e.g. speed & volume
• according to customer
  – e.g. student/seniors discount vs business premium
    (accept connections to servers; static addresses)
  – even if service/use levels (=> provision cost) are same

† Service provider probably focuses on return (profit) on investment, not revenue. Assuming don’t serve customers who give low (or negative) return, increasing revenue for actual customers should increase return
Price differentiation

1 price: 10 @ $10ea = $100
3 prices: 5@$15 + 5@$10 + 5@ $5 = $150
TELE9752 2011 survey (Q3)

Question 3

What is the most that you would be prepared to pay (in $) each month for unlimited Internet access?

![Graph showing ranked demand and price]
Telstra: business 60%> personal

**Business Broadband Plans**

<table>
<thead>
<tr>
<th>Monthly Included Data</th>
<th>Monthly Fee (24 month term)</th>
<th>Usage allowance</th>
<th>Plan term</th>
<th>Cost per month with BigPond Broadband Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>10GB</td>
<td>$60</td>
<td>5GB (then slowed to 64kbps)</td>
<td>24 months</td>
<td>From $29.95¹</td>
</tr>
<tr>
<td>25GB</td>
<td>$70</td>
<td>50GB (then slowed to 64kbps)</td>
<td>24 months</td>
<td>From $49.95¹</td>
</tr>
<tr>
<td>50GB</td>
<td>$80</td>
<td>200GB (then slowed to 256kbps)</td>
<td>24 months</td>
<td>From $69.95¹</td>
</tr>
<tr>
<td>100GB</td>
<td>$100</td>
<td>500GB (then slowed to 256kbps)</td>
<td>24 months</td>
<td>From $89.95¹</td>
</tr>
<tr>
<td>200GB</td>
<td>$110</td>
<td>N/A</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>300GB</td>
<td>$120</td>
<td>$7,440</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Unlimited</td>
<td>$310</td>
<td></td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

http://www.telstrabusiness.com/business/portal/online/site/productsservicesform2/orderitonline.528001
and http://go.bigpond.com/broadband/
Sample tariff: iiNet

Tariff may vary fee according to service level (typically throughput or monthly volume).

Choose between volume or speed

ADSL2 is faster and cheaper since using iiNet DSLAMs

http://www.iinet.net.au/broadband/plans.html
Adjust price points to reduce competition.

<table>
<thead>
<tr>
<th>iiNet</th>
<th>TPG</th>
<th>Optus</th>
<th>Dodo</th>
<th>Telstra</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADSL2+</td>
<td>ADSL2+</td>
<td>Naked broadband</td>
<td>Naked DSL</td>
<td>Bigpond Elite</td>
</tr>
<tr>
<td>$29.99</td>
<td>25+25</td>
<td></td>
<td>$27.90 2.5+2.5</td>
<td>5</td>
</tr>
<tr>
<td>$39.95</td>
<td>10+10</td>
<td>75+75</td>
<td>$37.80 5+5</td>
<td></td>
</tr>
<tr>
<td>$49.99</td>
<td>250+250</td>
<td></td>
<td>$47.80 50+50</td>
<td>50</td>
</tr>
<tr>
<td>$59.95</td>
<td>50+50</td>
<td>Unlimited</td>
<td>$57.75 3TB</td>
<td></td>
</tr>
<tr>
<td>$69.99</td>
<td></td>
<td>75+75</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>$79.95</td>
<td>100+100</td>
<td>250+250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$89.95</td>
<td></td>
<td></td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>$99.95</td>
<td>200+200</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[x+y = \text{peak} + \text{off-peak} \ (\text{GB})\]
Accounting for the time of day

Demand varies during the day:
• Business use peaks during day
• Residential use peaks in evening
=> Blend business + residential customers to maximise utilisation of infrastructure throughout day

Vary pricing during the day to even-out demand
Peak period (BHCA [30>) determines dimensioning for expected performance (“Contention rates” [VT>])
=> Peak & off-peak times <80]
Can substantially affect use [UT>]
Guess when access was unmetered?
Outline

End-user accounting
Plans and acquiring & keeping customers
Tariffs
  Vary prices (products) for different customers
  Choice of price (product) for a customer
  Anchors
  Decoys
Anchors

First impressions affect subsequent decisions
First price considered† might “anchor” price paid

Some anchoring methods:
• Sale!  
  Reg $48
  $40  $39  
  SALE
• Recommended Retail Price
• Expensive plans that exist to bias choice, rather than to attract buyers.

† “price tags by themselves are not necessarily anchors. They become anchors when we contemplate buying a product or service at that particular price.” – Ariely p. 30
Anchoring bids with social security #s

Average prices paid for the various products for each of the five groups of final digits in social security numbers, and the correlations between these digits and the bids submitted in the auction.

<table>
<thead>
<tr>
<th>Products</th>
<th>Range of last two digits of SS number</th>
<th>Correlations*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>00–19</td>
<td>20–39</td>
</tr>
<tr>
<td>Cordless trackball</td>
<td>$8.64</td>
<td>$11.82</td>
</tr>
<tr>
<td>Cordless keyboard</td>
<td>$16.09</td>
<td>$26.82</td>
</tr>
<tr>
<td>Design book</td>
<td>$12.82</td>
<td>$16.18</td>
</tr>
<tr>
<td>Neuhaus chocolates</td>
<td>$9.55</td>
<td>$10.64</td>
</tr>
<tr>
<td>1998 Côtes du Rhône</td>
<td>$8.64</td>
<td>$14.45</td>
</tr>
<tr>
<td>1996 Hermitage</td>
<td>$11.73</td>
<td>$22.45</td>
</tr>
</tbody>
</table>

*Correlation is a statistical measure of how much the movement of two variables is related. The range of possible correlations is between –1 and +1, where a correlation of 0 means that the change in value of one variable has no bearing on the change in value of the other variable.
Question 1
What are the last 2 digits of your student number? e.g. if your student # is z1234567, then enter "67".

Question 2
If your answer from Question 1 was the price in dollars that an ISP charged for monthly unlimited Internet access, then would you be prepared to use that ISP's service? i.e. do you think that that is a fair price?
- True
- False

Question 3
What is the most that you would be prepared to pay (in $) each month for unlimited Internet access?
Weak correlation between 9752 student # & price

Correlation coefficient: 0.3

(Student # mod 100)/10 rounded for privacy
Decoys

Hard to compare alternatives A&B across multiple dimensions. Apples vs oranges. Tempting to flatten to 1D, e.g. Uni rankings. **Decoys** are deliberately inferior to one alternative, to make that alternative appealing, & resolve dissonance by offering a clear answer (albeit irrelevant)

Figure from Ariely, p. 9
Economist subscriptions decoy

Extra context: This ad was online. “I am pretty certain that they wanted me to skip the Internet-only option (which they assumed would be my choice, since I was reading the advertisement on the Web) and jump to the more expensive option: Internet and print.” Ariely p. 2. [but in this case there are also more costs to the provider: hard copy]
### TPG pricing

<table>
<thead>
<tr>
<th>Plans</th>
<th>monthly Access Charge</th>
<th>Monthly Usage Quota * (Peak + Off Peak)</th>
<th>Shaping Speed</th>
<th>Sign Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADSL2+ Unlimited 24x7~</td>
<td>$29.99</td>
<td>Unlimited</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>ADSL2+ 500GB</td>
<td>$29.99</td>
<td>500GB^1 (250GB+250GB)</td>
<td>1Mbps/1Mbps</td>
<td></td>
</tr>
<tr>
<td>ADSL2+ 100GB</td>
<td>$19.99</td>
<td>100GB^2 (50GB+50GB)</td>
<td>256K/256K</td>
<td></td>
</tr>
<tr>
<td>ADSL2+ 20GB</td>
<td>$9.99</td>
<td>20GB^2 (10GB+10GB)</td>
<td>256K/256K</td>
<td></td>
</tr>
</tbody>
</table>

Hard to tell if need >100GB, or if 400GB is worth $10
Easy to tell that Unlimited is better than limited
Further encouraged by default sign up button

For when you need > 3TB/month

How much is 1TB?:
1 DVD = 2 hours video = 4.5GB
1TB/month = 33GB/day ≈ 8 DVDs = 16 hours = all waking hours

Google paid $0 to send terabytes

“loading all those thousands of servers with the indexes. That involved terabytes of data, which was potentially going to force Google to pay a huge amount of money ... To save money, Google ... exploited a loophole in the billing system for data transfer. Broadband providers used a system known as the 95th Percentile Rule. Over the period of a month, the provider would test how much information was moving, automatically taking a measurement every five minutes. In order to discard unusual spikes in activity, when the billing rate was calculated the provider would lop off the measurements in the top five percentiles and bill the customer at the rate of the 95th percentile.

Google ... decided to move all its information during those discounted spikes. “We figured out that if we used zero bandwidth all month, except for thirty hours once a month, we would be under that 5 percent,” says Reese. For two nights a month, from 6 p.m. to 6 a.m. Pacific time, Google moved all the data in its indexes from west to east. “We would push as fast as we could, and that would cause massive traffic to go across, but it was during the lull hours for them.... And of course, the bill came out to be nothing,” ... I literally turned off the router ports for twenty-eight or twentynine days a month.”

- S. Levy: In The Plex, p. 187
Outline

Access network accounting + more = AAA
ISP architecture

Backhaul to connect access networks

Transit across other ISPs to reach other destinations

Access Server => AAA [KD] > Architecture => costs [HW]

Access / subscriber lines

DSLAM = DSL Access Multiplexer

B-RAS = Broadband Remote Access Server

Base figure from Agilent whitepaper: “Understanding DSLAM and BRAS Access Devices”
AAA

ISPs need:

Authentication: Proving identity of user
Authorization: Determine whether a user is permitted to perform a particular action, e.g.
  • Post-paid: authentication => authorized (but must meter)
  • Pre-paid: after authentication, check for sufficient credit

Accounting: Tracking use/resource consumption by a user. Billing.

=> AAA protocols (e.g. RADIUS & Diameter) combine these functions
Remote Authentication
Dial In User Service (RADIUS)

Designed for dial-in users, but still used† for modern access, e.g. Telcos (ISPs+cellular), Uniwide, web sites

Architecture:
Access servers‡ are distributed:
× Insecure – accessible to users
× Inconsistent – potentially
AAA server is centralised (or hierarchical)
   Holds user & configuration data; checks for access svr
RADIUS used to communicate between access servers & AAA (RADIUS) server

RFCs: 2865: Remote Authentication Dial In User Service (RADIUS)
2866: RADIUS Accounting
† Increasingly through its successor, DIAMETER
‡ Originally “Remote Access Server”, then “Broadband RAS”, also (wireless) “Network Access Server”
RADIUS protocol example

Access Server  AAA Server  AVPs

Access-Request

Access-Reject or Access-Accept

Accounting-Request

Accounting-Request

Accounting-Response

Accounting-Request

Accounting-Response

User-Name
User-Password
NAS-Port
Reply-Message
Framed-IP-Address
Filter-Id
Session-Timeout, etc
Acct-Status-Type: Start
Acct-Session-Id
(None: just ACKs receipt)
Acct-Status-Type: Stop
Acct-Session-Id
Acct-Session-Time
Acct-Input-Octets
Acct-Output-Packets, etc
Acct-Terminate-Cause
RADIUS accounting request/response

Frame 3: 88 bytes on wire (704 bits), 88 bytes captured (704 bits)
Ethernet II, Src: Private_00:00:01 (00:01:01:00:00:01), Dst: Private_00:00:02 (00:01:01:00:00:02)
Internet Protocol, Src: 127.0.0.1 (127.0.0.1), Dst: 127.0.0.1 (127.0.0.1)
User Datagram Protocol, Src Port: 45298 (45298), Dst Port: radius-acct (1813)

Radius Protocol
Code: Accounting-Request (4)
Packet identifier: 0x2 (2)
Length: 46
Authenticator: 7b994a376c10fa309153ab461d25ed28
[The response to this request is in frame 4]

Attribute Value Pairs
AVP: l=4  t=User-Name(1): mu
AVP: l=6  t=NAS-IP-Address(4): 127.0.0.1
NAS-IP-Address: 127.0.0.1 (127.0.0.1)
AVP: l=6  t=Acct-Status-Type(40): Stop(2)
Acct-Status-Type: Stop (2)
AVP: l=10 t=Acct-Session-Id(44): 9668ab55
Acct-Session-Id: 9668ab55
Diameter

Succeeds RADIUS. Supports RADIUS AVPs + more

**What’s new:**
- Reliable transport (TCP or SCTP, port 3868) not UDP
- Secured by IPSEC or TLS
- Attribute Values can exceed 255 bytes
- Server-initiated messages, e.g. terminate connection

“base protocol” [RFC 3588] supports “applications”, e.g.:
- RFC 4005: Diameter Network Access Server App., including accounting request/answer like RADIUS
  - START&STOP + INTERIM_RECORD (during session) + EVENT_RECORD (simultaneous start+stop)
- RFC 4006: Diameter Credit-Control Application
  - Check costs & user credit; request&grant service →

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3 requests:
1. Initial
2. Update
3. Termination
+ answers

Service-Unit:
Here: CC-Money
(356 = Indian Rupees)
Alternatives:
CC-Time
CC-Total-Octets

[Request In: 1]
[Response Time: 0.021145000 seconds]

AVP: Session-Id(263) l=29 f=-M- val=nxl;api;1263278878147
AVP: Result-Code(268) l=12 f=-M- val=DIAMETER_SUCCESS (2001)
AVP: Origin-Host(264) l=26 f=-M- val=dslu.comverse.com
AVP: Origin-Realm(296) l=20 f=-M- val=comverse.com
AVP: Auth-Application-Id(258) l=12 f=-M- val=Diameter Credit Control (4)
AVP: CC-Request-Type(416) l=12 f=-M- val=INITIAL_REQUEST (1)
   AVP Code: 416 CC-Request-Type
   AVP Flags: 0x040
   AVP Length: 12
   CC-Request-Type: INITIAL_REQUEST (1)
   AVP: CC-Request-Number(415) l=12 f=-M- val=0
   AVP: Origin-State-Id(278) l=12 f=-M- val=16749
   AVP: Event-Timestamp(55) l=12 f=-M- val=Jan 12, 2010 06:49:09.000000 UTC
   AVP: Validity-Time(448) l=12 f=-M- val=5
   AVP: Granted-Service-Unit(431) l=52 f=-M-
   AVP Code: 431 Granted-Service-Unit
   AVP Flags: 0x040
   AVP Length: 52
   □ Granted-Service-Unit: 0000019d40000002c000001bd40000018000001bf40000010
   AVP: CC-Money(413) l=44 f=-M-
       AVP Code: 413 CC-Money
       AVP Flags: 0x40
       AVP Length: 44
       □ CC-Money: 000001bd40000018000001bf400000100000000000000000002...
       AVP: Unit-Value(445) l=24 f=-M-
       AVP: Currency-Code(425) l=12 f=-M- val=356
Outline

Service provider costs

Non-network
Network
  Access
  Backhaul
  Transit
  Peering
Service provider costs

$50.95 ARPU
26% profit

Non-network costs

• Acquiring customers
• Customer support. Around $4.50†
• Business overhead: Accounts, interest, depreciation, etc
• NOC!

Network costs: traffic (volume+rate) + capex + maintain

• Access. Around $28 for DSL†
• Backhaul. Around $5.50†
• IP transit. Around $5.10†

“on-network” traffic cheaper than “off-network” traffic

Especially for voice: Customers can distinguish on vs off

Viral marketing: Cheap calls to friends on-network

Estimates are the median (across different ISPs) costs/customer/month from Market Clarity [Mkt]
Access: Twisted pair

Telstra owns last mile copper
ACCC regulates pricing of last mile access due to competitive barriers:
$16.75: Unbundled Local Loop (ULL)
$25.40: Wholesale DSL – inner city
$30.80: Wholesale DSL – suburban
Dimensioning backhaul/transit

**ISP traffic costs [Mkt]:**

- **Backhaul:** $39.33/Mbps/month
- **Transit:** $45/Mbps/month

$40/Mbps/month => $1 per 8GB *if* very elastic!

**2 factors:**

- **Volume** (GB): Average 19GB/month [*ABS report 8153.0*]
- **Rate** (Mb/s):
  - Peaks occur at certain times of day <MM]
  - Unlikely for all clients to need line speed at same time
  - Save $: Size backhaul/transit < #customers * 10Mb/s
e.g. 161kbps/customer [Mkt]

"**Contention ratio**" = possible-demand/capacity, e.g. 60:1
Peering

ISPs need to interconnect to each other to create an *Inter*network. May act as customers to other interconnecting ISPs:

- Interconnecting ISPs may charge more for *transit traffic* (to other ISPs) than for *terminated traffic* (to their customers) (e.g. to reduce load so that they can better serve their own customers).
- ISPs that communicate sufficiently often may prefer to “peer”: Interconnect directly and not charge each other.

Figure from G. Huston: “Interconnection, Peering and Settlements—Part I”, *The Internet Protocol Journal*
End of accounting