Profiting from Innovation

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The Grand Convergence is Driven by:

- Digital data and signals, which provide a common (0,1) base for handling diverse types of information, including words, sounds, and images
- Widespread use of common standards, which allows connectivity between diverse information devices
- The advance of enabling technologies, including computers, data storage, batteries, and wireless communications.

Profiting from Innovation Independent Variables

1. Appropriability
   - Inherent Imitability
   - Intellectual property

2. Standards

3. Complementary Assets

4. Timing

More on Standards

	Industrial Economy Notion	**Knowledge Economy Notion**
	STANDARD SETTING ORGANIZATION (e.g. SAE)	STANDARDS DEVELOPMENT ORGANIZATION (e.g. IEEE/ETSI)
Compatibility Issues Implicated	Yes	Yes
New Technology embedded in Standards	No	Yes

More on Standards, con't.

	Two Paradigms of Standards Activities	
	Standard Setting (SSO)	Standard Development (SDO)
Process	Selection amongst known alternatives offered by contributors (inventive component small or non existent) Choices surrendipidous… no clear winner	New technologies developed, often at great expense to the contributors. Std Adopted because it's clearly superior
Outcomes	Uniformity, compatability	Innovation, conformity, compatability
Pricing	Usually zero (patents & trade secrets only rarely implicated)	FRAND
Examples	Left/Right hand side driving, SAE component Standards, British v American Electrical outlets	3G, 4G, 802.11 wifi

Enabling Technologies & GP Technologies

Enabling Technologies (and General-Purpose Technologies)
An enabling technology is an innovation that can be used to drive radical change in technological capabilities. It allows development of derivative technologies, often in diverse fields. Examples include the printing press, the steam engine, the transistor, and the microprocessor. Enabling technologies were not the focus of PFI, which looked at commercially viable product innovation.

General Purpose Technology:
Enabling technology is related to general-purpose technology (GPT), a broader category of innovations that have an economy-wide impact. A characteristic of both is that there are large positive spillover effects. Put differently, appropriability is weak for enabling and general-purpose technologies. This implies that society will not produce enough of them, absent government support.

GPT’s Have 3 Characteristics

1. Pervasiveness
2. Potential
3. Enhance Research Productivity

Complementary Assets

“The time is ripe for a fresh, modern look at the concept of complementarity … the last word has not yet been said on this ancient preoccupation of literary and mathematical economists. The simplest things are often the most complicated to understand fully.” (Samuelson, 1974, p.1255)

Types of Complimentarities

- **Hicksian Complementarity**: Factors of production are Hicksian complements when a decrease in the price of one factor leads to an increase in the quantity used of the others. An innovation that reduces the cost of a factor is equivalent to a decline in the factor's price.

- **Edgeworth/Pareto Complementarity**: Two goods, X and Y, are Edgeworth complements in consumption if the utility of consuming them together is positive, i.e., $U_{xy}>0$. Complementarity is symmetric; the quantity demanded of either good is affected by a change in the quantity demanded of the other. In Edgeworth's broader conception, complementarity does not require the existence of prices or even quantities; complements can include non-priced items such as government policies, or organizational structures. Milgrom and Roberts (1994) expand the definition beyond dyads. They define a group of activities as Edgeworth complements if doing more of any subset increases the returns to doing more of any subset of the remaining activities. They note that it is overly restrictive to assume that choice variables can be considered in isolation.

Types of Complimentarities, con't.

- **Hirshleifer Complementarity**: This is a theoretical type of complementarity based on anticipated interactions that can nonetheless be used to profit from an innovation. Invention creates foreknowledge about how asset prices might move. An economically rational inventor with financial means and foreknowledge (of their own invention) could gain additional value by going long in asset markets that would be positively impacted by the invention and/or short in markets that would be negatively impacted. This model of anticipated complementarity was in fact invoked in the original PFI article by noting that the innovator could speculate, where futures markets were available, on complementary assets that were likely to increase in value (Teece, 1986, p.295). Hirshleifer (1971) illustrates this principle with an analysis of Eli Whitney, who received a patent for the cotton gin in 1794 yet died poor 30 years later after dissipating his profits in litigation over patent infringement. Hirshleifer points out that Whitney could have foreseen the negative effect his invention would have on the price of cotton and the positive effect on the price of land and then speculated accordingly on either or both.

Types of Complimentarities, con't.

- **Cournot Complementarity**: Two products are Cournot complements if they are used together but sold by separate companies with monopoly power. Consider, for example, the case where each firm has a monopoly over one of two inputs used to make a product. If the companies are unable to collude, they will charge prices that maximize their individual profits considered in isolation yet fail to maximize their collective profit. This problem arises in the PFI framework when there are two or more bottleneck assets needed to produce an innovative product, and they are owned by separate parties. Whereas common ownership would lead to charging a monopoly price, the separate firms, absent collusion, might charge a higher price and lower their total profit, harming consumers as well. This is an interesting theoretical puzzle but not likely to be of practical significance [BECAUSE???].

- **Technological (Teecian) complementarity**: Technological complementarity occurs when the value of an innovation depends on altering the nature of one or more existing technologies and/or on creating new ones. This type of complementarity has nothing to do with prices and quantities. It applies when the full benefit (or even any benefit) of the innovation cannot be achieved until some other, complementary technology (which has independent, lower value uses on its own) has been created or re-engineered. This is in fact typical of enabling technologies. For example, realizing the full value from the introduction of electricity required the creation of electric motors that could be attached to machines. The "more than the sum of its parts" effect of technological complementarity is a supply-side innovation externality very different from the social benefit spillovers on the demand side.

Conclusion

For the most part, the same considerations apply at the regional ecosystem and national levels. Intellectual property rights, standards, market timing, imitability, and complementary assets are still relevant, although each factor operates somewhat differently. The most interesting alteration is that the complementarity of assets and technologies becomes even more salient:

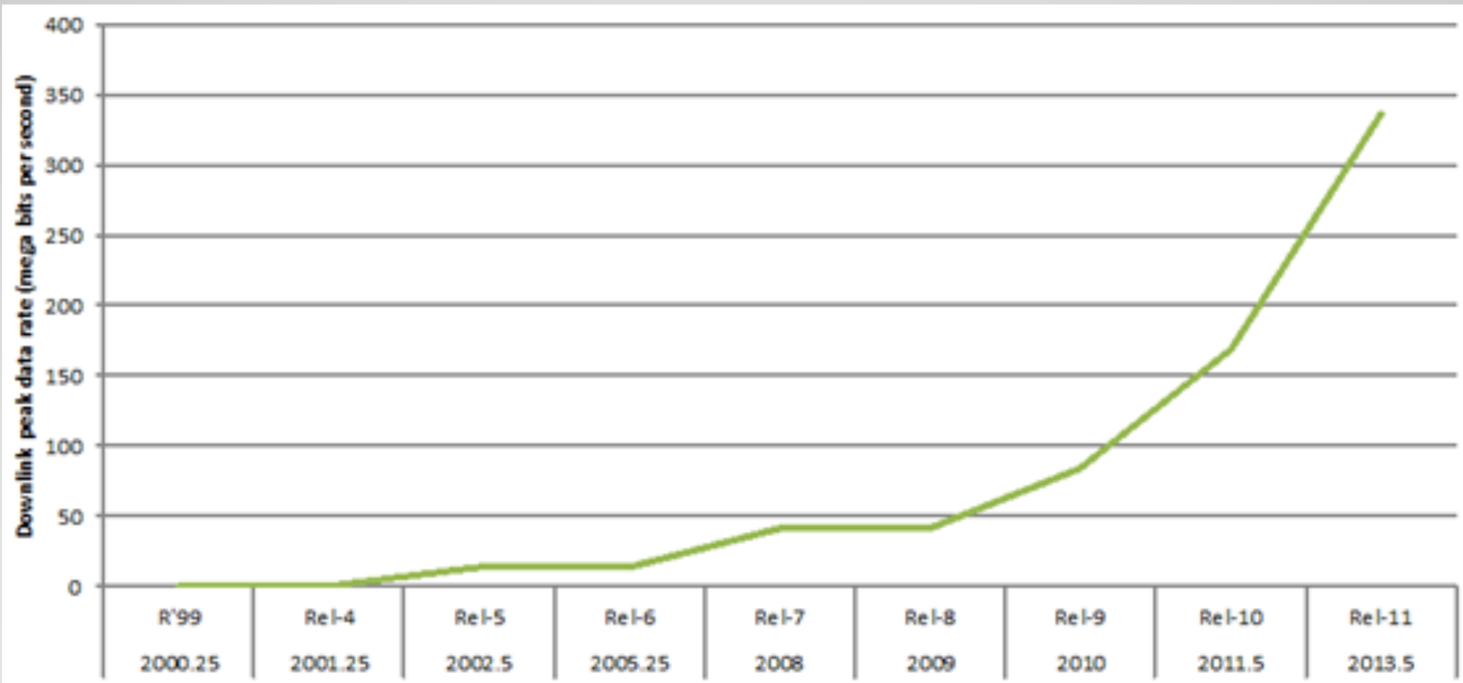
- Ecosystem success depends on complementary activities and virtuous circles (for example, digital content, digital rights management, and smartphones);
- Ecosystems can be proprietary or open (e.g., LTE versus Bluetooth) [IS THE IDEA HERE THAT LTE RUNS ON PROPRIETARY CONTRIBUTED TECHNOLOGY AND BLUETOOTH IS DEVELOPED BY ERICSSON, WAS PUT INTO THE PUBLIC DOMAN (I.E. ROYALTY FREE IMPLIED LICENSE)]
- Edgeworth complements and Cournot complements are largely irrelevant to the innovation context. Systems integration is one point where information sharing can occur without collusion on price.
- The mobile telephone case show that profits can be earned in different ways and at different levels of the ecosystem.
- Ecosystem health requires that continued development of enabling technology gets supported.
- The social returns to enabling technology in an ecosystem context are likely much greater than the private returns—even more so than for a discrete product.
- A general theory of PFI needs to grapple with innovation at five levels:
    - individual innovation
    - firm
    - ecosystem
    - regional or national system of innovation
    - international (global) system of innovation

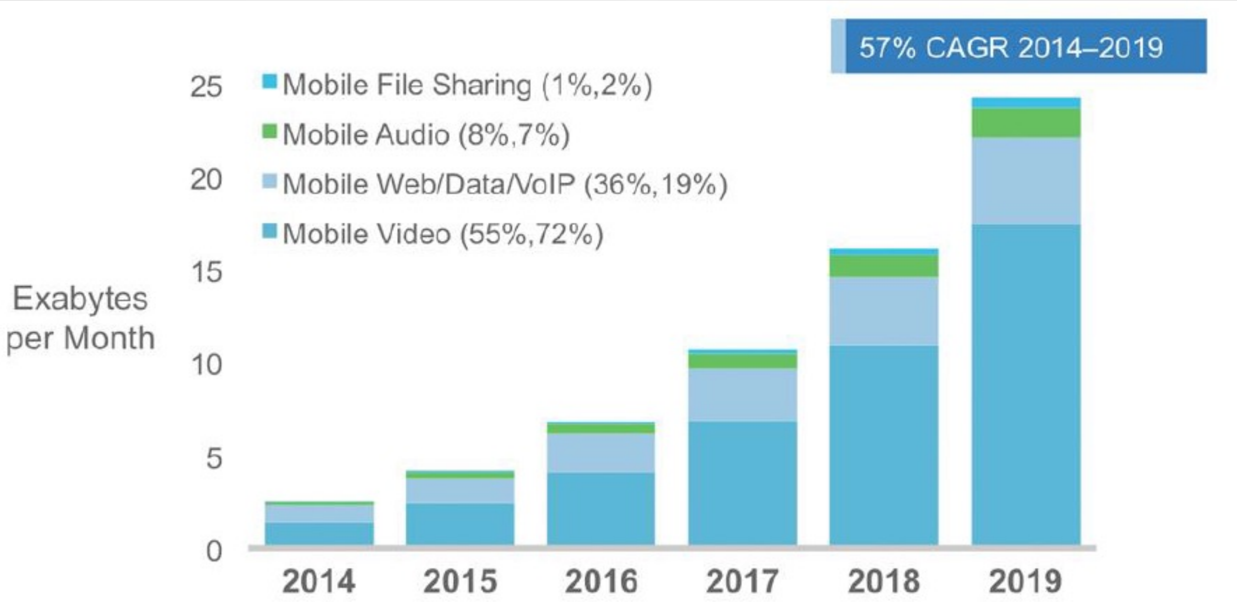
Appendix

Evolution of technology generations in terms of services and performance

Generation	Primary services	Key differentiator	Weakness (addressed by subsequent generation)
1G	Analogue phone calls	Mobility	Poor spectral efficiency, major security issues
2G	Digital phone calls and messaging	Secure, mass adoption	Limited data rates – difficult to support demand for internet/e-mail
3G	Phone calls, messaging, data	Better internet experience	Real performance failed to match hype, failure of WAP for internet access
3.5G	Phone calls, messaging, broadband data	Broadband internet, applications	Tied to legacy, mobile specific architecture and protocols
4G	All-IP services (including voice, messaging)	Faster broadband internet, lower latency	?

Increases in peak-data-rates for 3G mobile wireless networks





Figures in parentheses refer to 2014, 2019 traffic share.
Source: Cisco VNI Mobile, 2015

Operating Profit Margins and R&D Intensity by Group (%)

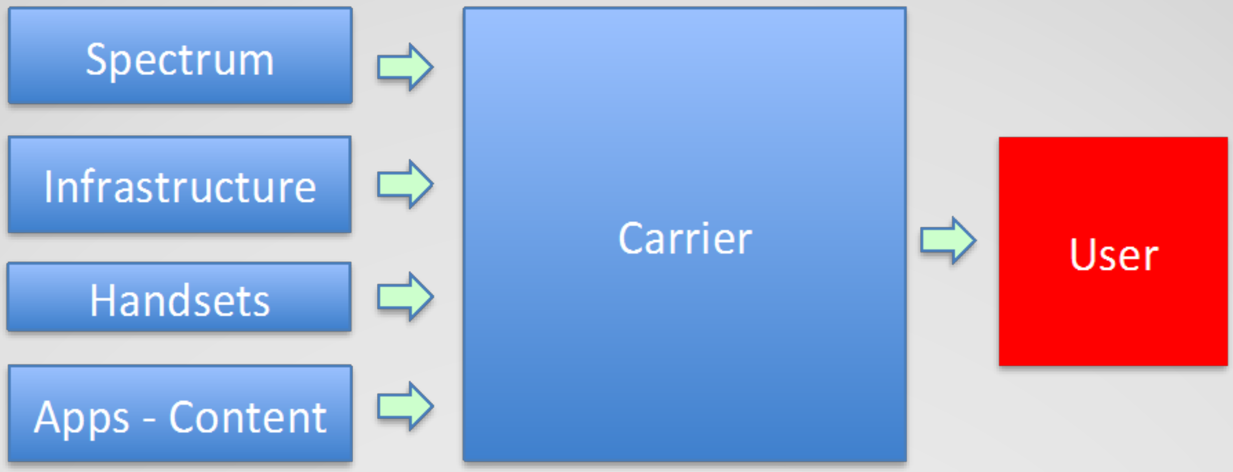
Operating Profit Margin %	2004	2005	2006	2007	2008	2009	2010	2011	2012	Avg
Component Manufacturers	5.2%	6.4%	6.3%	6.6%	4.1%	2.3%	9.5%	7.7%	6.2%	6.0%
Device Implementers	8.6%	8.5%	9.0%	9.8%	9.0%	5.2%	9.1%	10.3%	9.8%	8.8%
Infrastructure Implementers	7.4%	8.0%	7.9%	8.2%	7.5%	7.1%	8.8%	8.9%	6.3%	7.8%
Mobile Service Providers	15.2%	22.3%	21.5%	23.9%	21.1%	14.4%	17.5%	20.2%	2.4%	17.6%
Network Operators	14.3%	18.2%	11.6%	15.6%	13.9%	15.5%	16.4%	14.2%	13.8%	14.8%
Other	17.9%	22.1%	20.1%	20.8%	17.3%	9.0%	14.8%	16.0%	13.1%	16.8%
Total	10.5%	12.0%	10.2%	11.8%	10.5%	9.0%	11.7%	11.4%	10.0%	10.8%

R&D Intensity %	2004	2005	2006	2007	2008	2009	2010	2011	2012	Avg
Component Manufacturers	8.8%	8.8%	9.5%	9.6%	8.7%	10.0%	9.3%	9.6%	11.6%	9.5%
Device Implementers	6.7%	6.0%	5.4%	5.4%	4.8%	6.2%	5.9%	5.8%	6.0%	5.8%
Infrastructure Implementers	6.1%	5.8%	6.2%	6.1%	5.5%	6.8%	5.4%	6.3%	5.7%	6.0%
Mobile Service Providers	n/a	2.0%	1.6%	1.1%	1.1%	2.1%	3.1%	3.1%	13.3%	3.4%
Network Operators	3.6%	3.5%	3.6%	4.1%	2.0%	3.6%	3.6%	3.8%	3.8%	3.5%
Other	4.1%	3.7%	3.2%	3.0%	5.2%	4.4%	6.0%	5.2%	3.8%	4.3%
Total	5.9%	5.6%	5.5%	5.5%	4.4%	5.9%	5.6%	5.9%	5.9%	5.6%

R&D spending and intensity for leading firms (2012)

Company	R&D ($bn)	% Sales
Alcatel-Lucent	3.1	16.9%
Apple	3.4	2.2%
Ericsson	4.6	14.0%
Huawei	4.7	13.7%
Nokia	6.1	15.8%
Qualcomm	3.9	20.5%
BlackBerry	1.5	8.3%
Samsung	10.1	5.7%
ZTE	1.4	10.4%
Google	6.8	13.5%
Microsoft	9.8	6.0%
Total/ Avg. (wtd.)	55.4	11.5%

Traditional Market Organization in U.S.A. Mobile Markets



Evolving Organizational Structure as Haps Come To U.S.A. Mobile Markets

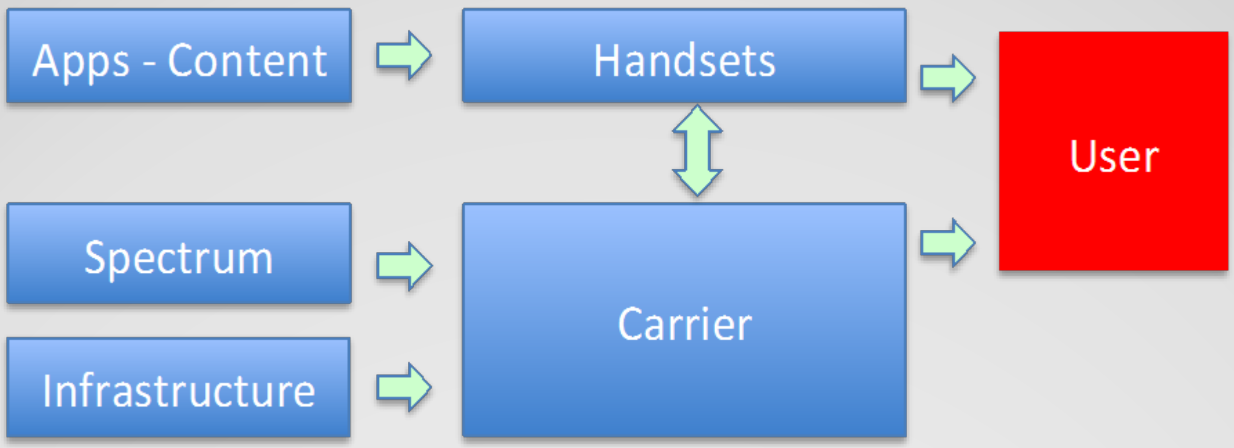


Table 1. Selected q ratios for Wireless Ecosystem Players					
Security	2008	1Q2009	2Q2009	Ratio to SP500 (2Q2009)	Enterprise Value ($bil.; 5.4.10)
Sprint	.6	.6	.5	0.68	28.9
Apple	2.6	2.5	3.1	4.25	212.2
RIM	5.0	4.6	6.2	8.49	~38.5
Nokia	1.0	.9	1.2	1.64	~41.5
MOTO	.7	.5	.3	0.41	11.7
QCOM	2.5	2.7	3.2	4.38	50.7
S&P 500	.55	.61	.73	1.0	

Source: Manual of Ideas (Sept. 21, 2009)