

Forking, Fragmentation, and Splintering

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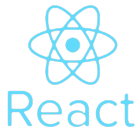
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Four Paths to Compatibility (Farrell & Simcoe, 2012)

- ▶ Follow the Leader
 - ▶ **Platform Leader**, Gov't, Customer
- ▶ Standards Wars
- ▶ Standard Setting Organizations
- ▶ Converters & Multi-homing

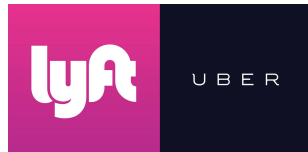


Should we also classify persistent incompatibility?



Incompatibility

- ▶ Despite compatibility avenues, persistent incompatibility common
- ▶ Often come in familiar flavors
 - ▶ Uber/Lyft, Spotify/Apples Music/Google Play
 - ▶ Electrical sockets/plugs
 - ▶ Cryptocurrencies
- ▶ Fragmented terminology in literature on platform forking, fragmentation, and splintering
- ▶ Policy relevance, e.g., Google



This paper: Forking, fragmentation, and splintering

- ▶ What are the key modes of incompatibility?
 - ▶ Forking
 - ▶ Fragmentation
 - ▶ Splintering

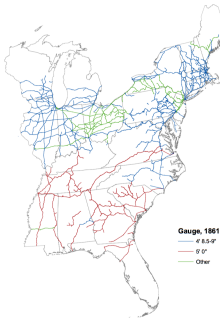
	Differ on...	Game	# Players	Equilibrium
Splintering	Standard	B.o.S.	Many	Pure strategy
Fragmentation	Standard	B.o.S.	Few	Mixed Strategy
Forking	Interoperability	P.L.B.	Few	Mixed Strategy

Splintering: a model

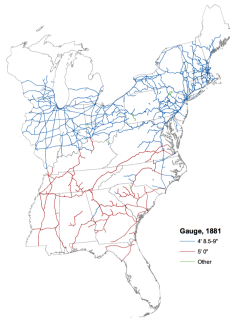
- ▶ Many players, choosing discrete technologies
- ▶ Payoffs
 - ▶ Player i receives $\$2 \times \#$ number of players that choose technology j , plus $\$3$ if j is preferred technology of i
- ▶ Strategies
 - ▶ Coordination on one technology $\Rightarrow$ Nash equilibrium
 - ▶ Non-coalition proof pure-strategy equilibrium $\Rightarrow$ Splintering
Pareto dominated equilibrium
- ▶ Key features:
 - ▶ Decentralized adoption
 - ▶ Design-specific investment $\Rightarrow$ switching costs $\Rightarrow$ lock-in

Splintering: railroads (Gross, 2016)

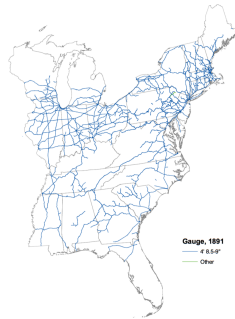
Baseline: 1861 Railroad Network



Updated Railroad Gauges of the 1861 Network, as of 1881



Updated Railroad Gauges of the 1861 Network, as of 1891



Southern Rail and Steamship Association: May 31, 1886

Splintering: early automobiles (Thompson, 1954)



Splintering takeaway

- ▶ Splintering the result of...
 - ▶ Decentralized decision making
 - ▶ Technical uncertainty
- ▶ Resolved via...
 - ▶ Endogenous problem solving
 - ▶ SSO (SAE), or monopoly leadership (Railroads)
 - ▶ But, slow path to compatibility

Fragmentation: a model

		Player 2	
		A	B
Player 1	A	$(10 + x, 10)$	$(0, 0)$
	B	$(0, 0)$	$(10, 10 + x)$

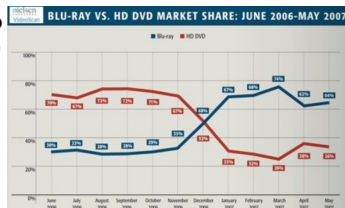
- ▶ Strategies
 - ▶ Pure strategy equilibria $\Rightarrow$ Coordination
 - ▶ Mixed strategies $\rightarrow$ Fragmentation (pareto dominated)
 - ▶ Players choose preferred technology with $p = \frac{10+x}{20+x}$
 - ▶ $\Pr(\text{fragmentation}) \xrightarrow{p} 1$ as x grows
- ▶ Key features
 - ▶ Small # key players
 - ▶ Strong vested interest (x), e.g., patents/IPR

Fragmentation: examples

- ▶ 56K Modems (Greenstein & Rysman, 2007)
 - ▶ US Robotics Vs. Rockwell
 - ▶ Patents $\Rightarrow$ Deadlock
 - ▶ Two standards: X2 vs. Flex (1997)
 - ▶ ISPs divide, AOL waits
 - ▶ ITU compromise: V.90 (1998)



- ▶ Blu-ray vs. HD-DVD
 - ▶ Two consortia
 - ▶ Patent licensing incentives
 - ▶ Importance of content/studios
 - ▶ Sony Playstation



Fragmentation wrap up

- ▶ Characterized by
 - ▶ Often at point of technical upgrade
 - ▶ Few key players, differing over small set of options
- ▶ Uncertainty over standard $\Rightarrow$ market hesitation
 - ▶ Urgency to resolve fragmentation
 - ▶ Standard setting committee, standards war

Forking: a model

		Player 2	
		A	B
Player 1	A	(10, 0)	(0, 10)
	B	(0, 10)	(10, 0)

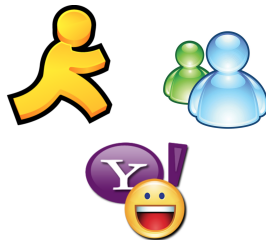
- ▶ Strategies
 - ▶ No pure strategy equilibrium
 - ▶ Mixed strategies $\Rightarrow$ players play both technologies with $p = 0.5$
- ▶ Key Features
 - ▶ Cat/Mouse
 - ▶ Disagree over interoperability
 - ▶ Need change in payoffs for stable compatibility
 - ▶ Preventing proprietary networks/emergence of competing networks

Forking: examples

- ▶ MS and Java
 - ▶ “Embrace, extend, & extinguish”
 - ▶ Importance of market power
 - ▶ Fighting for what? Developers.
 - ▶ Private case $\Rightarrow$ \$2B settlement



- ▶ Instant Messaging
 - ▶ ICQ, PowWow, AIM
 - ▶ Killer App = “Buddy List”
 - ▶ AOL-Time Warner Merger (FCC)
 - ▶ Names & Presence Directory (NPD)



Forking: wrap up

- ▶ Forking characteristics
 - ▶ Fundamental disagreement on interoperability
 - ▶ Cat and Mouse game
- ▶ Resolution?
 - ▶ Payoff structure changes
 - ▶ Gov't intervention, antitrust
- ▶ Open source (e.g., GPL)
- ▶ Distinguishing exclusion from platform vs. disagreement over technical direction

Policy Implications?

- ▶ Preference for compatibility, recognizing that “good forks” can occur under certain conditions:
 - ▶ High demand for variety
 - ▶ Added functionality without degrading rivals
 - ▶ Lots of uncertainty
 - ▶ Cheap converters or multi-homing
- ▶ Complex trade-offs
 - ▶ Variety vs. Compatibility, Innovation vs. Competition
- ▶ Recent examples
 - ▶ Android anti-forking provisions
 - ▶ API copyrightability (e.g., Oracle v Google)

Thanks

Thank you!

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