

Response to the FCC NPRM on Open Internet prepared by Richard Ma (tbma@comp.nus.edu.sg) and Vishal Misra (misra@cs.columbia.edu)

1. Para. 1: From the first sentence, the proposed rulemaking emphasizes “broadband investment and deployment”. It seems that the scope is really limited to broadband or eyeball ISPs. We want to emphasize that the net neutrality issues are not limited to broadband. Many core issues are involved with transit ISP and content providers as well. When it mentions “open”, does it mean “neutral”? If it is not “open”, is the current Internet “closed”? It seems that “open” is not well-defined. We comment that “open” should be defined more clearly.
2. Para. 2: “What is the right public policy to ensure that the Internet remains open?” Again, to answer this question, we first need to be clear about the definition of “open”.
3. Para. 3: The no-blocking rule is too limited. An ISP could give extremely small amount of capacity for certain content traffic, which does not block it; however, the resulting quality might be too poor for users to make use of the content. “Commercially unreasonable actions” needs a clear definition and interpretations.
4. Para. 4: “the best ways to define, prevent ... the practices that threaten an open Internet”. We suggest that the openness should be defined based on the level of market competition. Our work [1] has shown that whether regulations are needed really depends on whether market competition exists or not.
5. Para. 6: In general, access ISPs do have incentives to maximize their revenue by differentiating services, which might or might not be beneficial for the end-users; however, this is different from being “open” or not. There is a zero-sum game between the edge and access providers, therefore, it ultimately is a profit sharing problem [3, 4]. With respect to the second point, our recent work [2] studies paid prioritization on edge providers and from a social welfare perspective, our results support the use of priority-based pricing and service differentiation rather than imposing net neutrality regulations. With respect to the third point, our work [1] confirms that without market competition, a monopoly ISP does have incentives to make free ordinary services “damaged good”; however, market competition could avoid such a scenario.
6. Para. 10: “First, we generally propose to retain the definitions and scope of the 2010 rules.” We comment that the scope could be broadened and the definition of “open” should be made more clearly. “Second, ... should enhance the transparency rule ...” We agree with this which will enhance the competition among the ISPs. “Third, ... no-blocking rule ... with a revised rationale, in order to ensure that all end users and edge providers can enjoy the use of robust, fast and dynamic Internet access.” It seems that the proposed requirement is a lot more than a no-blocking requirement. “Fourth, ... to adhere to an enforceable legal standard of commercially reasonable practices ..., asking how harm can best be identified and prohibited and whether certain practices, like paid prioritization, should be barred altogether.” Again, we comment that a more clear definition of “commercially reasonable practice” is needed. In our work [1], we show that paid prioritization does not harm user welfare unless the access ISP is a monopoly which makes a lower-class service “damaged good”. We suggest that a service comparison between the different service classes can be used as a guideline to limit service differentiations. In our recent work [5], we propose to limit the quality difference, rather than the absolute

quality level, to ensure the “commercial reasonable actions”. “Fifth, ... dispute resolution process”. Our prior work [3, 4] looked into the ISP settlement issues and identify that the Shapley mechanism could be an ideal mechanism to arbitrate disputes among interconnecting ISPs to maximize the social welfare. This can be practically difficult so the correct approach should be to increase competition at the access which obviates the need for any dispute resolution.

7. Para. 12: “consumers’ hunger for high-value content”. Net neutrality could hurt when low-value content compete with high-value content and reduce them via negative network effect, i.e., congestion. Allowing ISPs’ differentiation could prioritize high-value content to end-users.
8. Para 13: the original purpose is to “encourage broadband deployment”. Too restrictive a policy will reduce the incentives of broadband providers to deploy in suburban areas.
9. Para 17: “stop blocking” is easy to achieve, however, the real question is about service differentiation. Could we allow ISPs to limit the throughput of certain applications? Maybe we could not let ISPs to “actively” limit the throughput, but they could maintain different service classes and let edge providers to choose the services. We proposed and studied this type of “passive” service differentiation in our work [1, 2, 5], and our results in general support ISPs to provide such differentiations as long as enough market competition exists.
10. Para 18: it all boils down to the question whether the network management is reasonable or not. By measuring the relative quality (throughput) between BT traffic and other traffic, as proposed in [5], one could infer whether the network management is reasonable. If we only look at the quality of BT traffic, even it gets low throughput, it might be because the system is limited in capacity and cannot support the demand (not because of ISP’s differentiation).
11. Para. 20: “nondiscrimination and transparency rules” We suggest that nondiscrimination should be defined to allow passive service differentiation [1, 2, 5], e.g., class-based service differentiation, under which content providers get to choose what service to use.
12. Para. 21: we want to comment that the 2nd case of “blocking” is a special case of the 3rd scenario of “unreasonable discriminating in transmitting lawful network traffic”. We need a definition of “unreasonable discrimination” and suggest use the quality difference in different services.
13. Para. 23: “... D.C. Circuit ... grant the Commission affirmative authority to encourage and accelerate the deployment of broadband capability to all Americans through, among other things, measures that promote competition in the local telecommunications market or remove barriers to infrastructure investment.” We totally agree with this view. Based on the results of our work [1, 2], we suggest that the FCC should promote competition rather than imposing restrictive rules on ISPs. “the court struck down the anti-blocking and anti-discrimination rules, explaining that the Commission had chosen an impermissible mechanism ... imposed per se common carriage requirements ... ” Based on our work [5], we suggest that the FCC should not impose strict service “requirements” on the providers. However, they could impose rules to restrict the quality difference among service classes. On the one hand, through this type of regulation, it does not impose a common carriage requirement. On the other hand, this type of regulation is also enforceable and provides ISPs spaces to differentiate services.
14. Para. 26: we want to comment that certain passive service differentiation does not necessarily mean “restricting edge providers’ ability to reach users ...”. Our prior work [1] showed that the

“short-term incentive to limit openness” does exist under a monopolistic market. However, if market competition is enough, this behavior will reduce the market share of the ISPs. We also showed that under market competition, ISPs will have incentives to differentiate services, resulting in an increase in the social welfare.

15. Para. 27: “... any small costs of imposing the rules were outweighed by the positive effect on network investment from the preservation of the openness that drives the virtuous circle ...”. We have mixed feelings on this. A strict rule might reduce the investment incentives of access ISP to deploy capacity to rural areas.
16. Para. 32: “tremendous growth in the online video markets ... revenues from online video services grew 175% from \$1.86 to \$5.12 billion ...” This causes congestion and unbalance in profit sharing, which reduces the investment incentives from access ISPs. Our prior work [3, 4] on Shapley profit-sharing indicates that a re-balancing is needed to compensate the access ISPs from the content side ISPs. This can be achieved in two ways, either by paid-peering arrangements or by increasing competition at the access.
17. Para. 33: we agree that competition should be encouraged; however, without incentives for ISPs to do service differentiation, they might not have any incentives to deploy infrastructure to rural areas. Also, natural monopoly exists in those areas, because a 2nd provider is basically too expensive. Regulating this natural monopoly could be different from regulating other ISPs; otherwise, no ISPs will be willing to deploy infrastructures in rural areas.
18. Para. 34: we want to comment on the role of the Internet’s openness in facilitating innovation, economic growth, competition and broadband investment and deployment. Here, we have conflicting roles of competition and broadband investment. Increasing competition on the broadband side might reduce their incentives to invest, but encourage more investments on the edge/content providers. However, lack of investment in infrastructure will eventually hurt the whole ecosystem, innovation and economic growth. We need to balance the different objectives. One solution is to look at both broadband providers and edge providers as a whole Internet supply chain, and think about the revenue/profit sharing among them, so as to maximize the utility of the overall ecosystem. Under such a macro model, we might allow broadband providers to differentiate services and charge edge providers.
19. Para. 36: the scope of the market between broadband and end-users is limited. No evidence exists for “pay-for-priority” on end-users. However, broadband is doing that on the peering side.
20. Para. 37: voluntary subsidization could be a useful mechanism, where the broadband still maintains a physically neutral network, while service differentiation is maintained at a higher economic layer. Product differentiation is not uncommon in other areas, e.g., first class airfare, student tickets, and etc. Our on-going work [6] analyzes the subsidization competition among the content providers when policy allows. Our preliminary results show that it could serve a (physically) neutral and viable mechanism to attract investment incentives for access ISPs. The danger is that new entrants in the edge provider market might find it difficult to compete with established players with deeper pockets.
21. Para 40: The European ISPs have to unbundle their local loops, which creates competition among the providers. Thus, even when there is no policy to prohibit ISPs to block traffic, competition will drive them not to hurt user welfare, if such a blocking does so. This is

supported by our public option work [1] and the developments in the UK market [7]. On the other hand, the lack of competition in the US (because of no local-loop unbundling) makes policy more important. The problem is not about whether there are cases of blocking, but whether competition is enough for users to choose providers in case one of them is not satisfactory to the users.

22. Para 41: Again, the problem is related to the lack of competition. When AT&T is the only provider and it lacks capacity, there might be a good reason (network management, or economic) for it to restrict applications. It is difficult to judge whether such a restriction is good or bad. Without such a restriction, capacity-heavy application might affect the usage of other apps when the wireless capacity is limited. When competition is there, users will have choices to switch to another provider which might allow such apps, but probably with poorer quality. In a monopoly case, regulation needs to be carefully designed. If we want to guarantee a minimum service quality for apps, this threshold might depend on the capacity of the provider and other factors. Instead, we propose to limit the quality difference [5] among services rather than putting an absolute guaranteed minimum service quality for the free services.
23. Para 42: we do not agree that “the threat of ... Did not depend on ... market power”. In fact, that is the root cause. We have shown the impact of market power in our work [1, 3].
24. Para 43: we do not agree that “the commission need not engage in a market power analysis to justify its rules ...”. “the ability to block edge providers depended on “end users not being fully responsive to the imposition of such restrictions””, we comment that transparency is needed to make users to be aware of such restrictions. The no-responsiveness could be because the restriction does not affect users’ welfare/utility much and switching to another provider is not necessary. The real threat is that it matters to the users, but due to the lack of market competition and user choices, the users have to stay with the current provider.
25. Para. 44: “broadband providers have incentives and the economic ability to limit Internet openness ...” we comment that broadband providers do not have a direct incentive to limit openness, unless it is going to increase their profit/revenue. In a competitive market, they won’t have such incentives if users are sensitive to service quality. Also, broadband providers do not have strong incentives to limit the openness on the end-user side, but have more incentive to differentiate at the peering side with the edge providers, who might have much larger profit margins compared to the access providers. The changing market place, including the change in content, e.g. the rise of Netflix and CDNs, has affected the broadband peering strategies greatly. Technology-wise, it is not difficult to physically separate different capacities along different routing paths. With the emerging Software Defined Networking (SDN) approaches, ISPs might have stronger abilities to manage their network resources to differentiate their peering relationships with other ISPs/CPs. Our work [1] showed that by differentiate capacity at the CP-side, the ISP has incentives to do so to increase revenue under a monopoly setting. In particular, the ISP has incentives to make free/open class “damaged good” to force CPs to use premium class and pay, which might hurt social welfare. We showed that competition, e.g., the introduction of Public option, could solve the problem. Justification for charging edge providers could be the basic economic efficiency: capacity is limited, by differentiate high- and low-value traffic, the ISP could provide higher welfare to users and CPs.

26. Para. 45: Transit ISPs use parameters in BGP routing protocol to choose different routing paths. Access ISPs use public/private peering settings to control traffic. On the user-side, mobile providers use data cap to control and price traffic data. AT&T's sponsored data plan introduces voluntary subsidization from CPs to end-users for their over-cap traffic. As for the Comcast case, its private peering practice might be used to exploit their monopoly market power in the access market. Level3 data hints at that.
27. Para. 46: we do not have data to understand the switching costs. However, we support that transparency to be given to users, so that they understand more of their choices/options and improve the market competition.
28. Para. 47: "We seek comment on the state of competition in broadband Internet access service, and its effect on providers' incentives to limit openness." We guess many people will comment on the monopolistic status of Comcast. Our public option work [1] showed that the monopoly has incentives to differentiate service at the CP-side and show its incentives to make public peering "damaged good", which is claimed by Level3. Thus, we advocate a public option approach to introduce competition, under which no regulation is needed to monopoly. Otherwise, suitable regulation might be needed to regulate the monopoly. DSL's openness practice could incentivize high-speed broadband to differentiate CPs less aggressive, although another high-speed provider's competition will help more.
29. Para. 48: needs more market data for market competition analysis.
30. Para. 49: as our study [1] showed, market competition is a key to whether regulation is needed. We suggest that regulation should be closely coupled with market power analysis.
31. Para. 50: "there are other economic theories ..." 1) Shapley value for inter-ISP settlement [3, 4], and 2) public option [1] for access ISP service differentiation and competition, and 3) subsidization competition [6] among the content providers. Also, on the value of the network, the exact form of n^2 or $n \log n$ doesn't matter - the important theoretical distinction is whether the value of the network is a convex function of n or not - and both n^2 and $n \log n$ satisfy convexity.
32. Para. 51: technically, access ISP might be able to block end-user traffic; however, flow-based control is expensive and difficult for ISPs, and has little economic incentives to do so. ISPs largely use public/private peering nowadays to differentiate classes of traffic via inter-AS routing. The routing is currently based on BGP protocol, a rough tool to do fine grain flow-level control. Thus, we suggest the rules extend its scope to include inter-AS settlement and peering relationships.
33. Para. 52: yes, ISPs could use traffic management tools. However, most practices are simply macro-level private/peering relationships, where physical links are separated/isolated and no active differentiations are needed for the traffic flows.
34. Para. 59: ".. the rules were not intended "to affect existing arrangements for network interconnection, including existing paid peering arrangements"", we comment that the inter-connect agreement between the broadband and other transit ISPs should be included within the scope, otherwise, less could be done to limit the service differentiation done on the CP-side.
35. Para. 60: in general, a "specialized service" could be a prioritized service which brings extra revenue for the ISP and its users. However, as we showed in our work [1], ISPs might have incentives to make ordinary service "damaged good" so as to force users to use specialized

service and pay them. Thus, we might need to impose conditions under which specialized service could be provided.

36. Para. 62: this is reasonable and useful to distinguish mobile and fixed service providers, and based on their characteristics, e.g., cost structure and capacity, to impose different regulations, e.g., different minimum requirement for service and thresholds for service quality differences.
37. Para. 63-88: we general support the transparency in any aspect, as long as it's practically feasible. The main reason is that transparency could improve market completion, under which strict regulations might not even be needed.
38. Para. 89-109: blocking is definitely undesirable for users and CPs. However, the D.C. Circuit vacated the rule mainly because of the legal "common carriage" requirement, which the ISPs might not be responsible for. We do not oppose the proposed rule, however, it still does not have a legal justification and "a clarification ... does not preclude ..." makes the rule almost non-enforcing. To impose a minimum level of service is encouraging; however, the legal justification is still missing and what this level to set needs further thoughts.
39. Para. 90: "relationship between no-blocking and commercially reasonable rules". No-blocking is a special case of the later.
40. Para. 101: "we seek comment on how minimum level of access should be defined". This is important. Different type of ISPs should have different thresholds. Different type of CPs might have different minimum requirements, although from a regulatory and practical perspective, it is difficult to set different requirements for each different CP. Furthermore, under sufficient competition, we think even the minimum requirements are not needed.
41. Para. 104: we agree that the requirement should also be evolving based on the changing characteristics of content and user expectations.
42. Para. 110-141: "Codifying an enforceable rule that is not common carriage per se". D.C. rejected prior rule based on "(it) so limited broadband providers' control over edge providers' transmissions that [it] constituted common carriage per se." from this perspective, I feel that a requirement of minimum service requirement is still like imposing a "common carriage" requirement on the ISPs, which does not have a legal justification for the FCC (although it might have its economic justifications). Therefore, in our work [5], we suggest a milder/weak, but enforceable rule, which restrict the difference in service qualities of the different services provided by the ISPs. If the ISP is really capacity constrained, then its premium service quality cannot be high, unless its ordinary service has to be maintained at certain level. The advantage is that it does not impose a fixed/hard requirement on the ISPs, and the rule is flexible for different types of providers, e.g., mobile provider might maintain lower QoS for ordinary (e.g., best-effort) and its premium service (e.g., 1Mbps), while high-speed broadband can provide very high-quality premium service (e.g., 10Mbps), when its ordinary service can guarantee already quite good service (e.g. 2Mbps). By imposing such a relative regulation, it does not impose any hard requirement for ISPs to fulfill. In comparison, minimum requirement rule read more like "you have to become a common carriage first, so as to be qualified to differentiate services". Both have similarities and differences in terms of justifications and practicality.
43. Para. 142-160: these are legal authority and considerations, not our expertise. We suppose the rule needs to avoid imposing "common carriage" kind of regulations to ISPs.

44. Para. 161-176: this is dispute resolution. We comment that our proposed Shapley value mechanism can be used for inter-AS dispute resolution. However, it is more on the peering side, not on the end-user side.

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