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ABSTRACT

Whether city governments should intervene and provide public funds for building Municipal Wireless Networks (MWN) is a controversial and important issue. Some people support the government's intervention because MWN services seem to fit in the "public goods" category and result in "positive externality" (Cornes and Sandler, 1986). However, others are suspicious of the efficacy of the government's intervention based on the competing New Institutional Economics (NIE) theory (Williamson, 2000; Cheung, 2002).

Backed with the theoretical arguments of property rights and transaction costs, we critique the welfare economics policy recommendation which calls for government interventions. We predict that city governments will contract with private firms in developing MWN and will contribute city owned radio frequency and streetlights in the production of MWN services. Our initial findings from an empirical study confirm this proposition. Our study contributes to the MIS research on the emerging phenomenon by introducing NIE and provides practitioners with valid policy recommendations.

Keywords

Municipal Wireless Networks, New Institutional Economics, property rights, transaction costs.

INTRODUCTION

Universal broadband Internet access will help a country to gain a significant advantage in the global competition (McChesney and Podesta, 2006). However, the United States is ranked 19th for household broadband penetration in the world, according to Telecompaper, a research firm and publisher specializing in telecommunication and Internet news (http://knowledge.wpcarey.asu.edu/index.cfm?fa=printArticle&ID=1183, 2006).

The characteristics of traditional wire network technology plus the density distribution of a community make certain areas unattractive to major telecom and cable companies. Because wiring those communities is too expensive and not profitable, these areas are left behind and are under served. Lacking access to high-speed Internet, some communities feel that they need to plan and build broadband networks themselves (Behm, 2004).

New wireless network technology

New wireless network technology, Wireless Fidelity (Wi-Fi), presents an opportunity to deploy new broadband Internet access services in areas previously viewed as unprofitable by traditional telecom and cable companies.

A Wi-Fi network is cheaper and easier to build compared to the traditionally wired network technology. While it might cost traditional cable and DSL companies millions of dollars to bring broadband to all residents of Cerritos, California, the Wi-Fi solution only costs tens of thousands. Moreover, it is easy to install a Wi-Fi network, unlike wired networks in which expensive cables must be laid underground. Thus, a Wi-Fi network can be deployed quickly as the builder does not need to dig underground to bury cables, according to Stan Hirschman, CEO of Wi-Fi start-up Aiirmesh (Kessler, 2004). Wi-Fi networks are also easy to use by the end users, who only need a Wi-Fi compatible network adaptor card. Currently the price of a Wi-Fi adaptor card is under $50.

Therefore, Wi-Fi technology is a viable technical choice for building a broadband network for under-served communities. In the past few years, dozens of cities in the United States have jumped on the MWN bandwagon.

Benefits of MWN

The exploding interest in creating Municipal Wireless Networks (MWN) indicates rationally expected benefits of MWN. According to Philadelphia's Mayor John Street, the main motivation of a MWN project is to narrow the "digital divide" – the gap between the fortunate ones who can afford high-speed Internet access and those low-income people who have no such ability. Cities with MWN will attract more potential business investments, opportunities, and travelers. MWN will also improve city workers' productivity by making it possible for them to update information in the field, thus saving commuting time (http://knowledge.wpcarey.asu.edu/index.cfm?fa=printArticle&ID=1167, 2006). Moreover, MWN will help to improve city image to retain and attract young professionals (Johnson, 2006A; http://knowledge.wpcarey.asu.edu/index.cfm?fa=printArticle&ID=1183, 2006). MWN could also facilitate local economic expansion and aid disaster response for homeland security (Johnson, 2006B). MWN will support innovative social and business applications (Mandviwalla and Jain, 2006). Another potential benefit of MWN is the ability to attract more tourists who otherwise have to find a commercial location that provides Wi-Fi access (Miller, 2005).

Research issues

Emerging wireless technology and the new development of MWN initiatives provide exciting research opportunities for academia to study the technology and the social, economical, legal, and political problems created by this new phenomenon.

The city government and its CIO both face technical and business decisions regarding building and operating MWN. Some of the questions they face include:

- What kind of technical infrastructure should be used for developing MWN? What are the technical risks, given the relative fast development of emerging wireless technology such as WiMax? What level of security should MWN have?
- What is the viable business model for providing MWN?
- Will public funds be used for MWN? Will city governments finance MWN with taxes or through issuing MWN bonds?
- Will the city government allow private firms to use the publicly owned radio spectrum and city owned street lights in the MWN production? Will the city government earn some rents from the deal?
- Will the city government rely on the private sector to build, operate and maintain MWN?
- To what extent will the city government be involved in the MWN project?
- Overall, the bigger question is, what role will the city government play in the MWN project?

In the next section we will present theoretical backgrounds from the "public goods and positive externality" side as well as from the "New Institutional Economics" side. We will then employ logical reasoning from the theoretical background to the specific issue of MWN. Following the theoretical arguments, we will deduct a proposition and imply what will be observed in the real world. Next, we will conduct several empirical case studies. We will discuss the findings in connection with the above economic theory. Finally, we will conclude the paper and point out the limitations and future research directions.

THEORETICAL BACKGROUND

Public goods

A public good is a good or service that is difficult to be provided profitably by private producers because it has two properties: non-rivalry and non-excludable (Cowen, 1988; Goldin, 1977; Wessks, 2000; West, 2000). Non-rivalry or jointness of consumption means one party's consumption of the public good does not diminish another party's consumption of the same public good. Non-excludable means it is very hard or expensive to exclude the non-payer from access to the public goods once it is produced and released. Examples of classic pure public goods include national defense, law enforcement, and online database information (West, 2000).

Because it is expensive or impossible to exclude the non-payer from accessing and enjoying the public goods, the producer of public goods will be under compensated. Thus, the producer of public goods has less incentive to produce the socially optimal amount of public goods resulting the under production of the public goods. This leads to market failure and inefficiency in resource allocation. The root reason is the existence of positive externality, that is, the private producer of the public goods cannot fully receive all the benefits of the production (Flynn, 2005).

Positive externality

When the producer of public goods cannot reap all of its gains from its action, positive externality occurs. Positive externality is the uncollected benefit external to the producer. The free rider gets a spillover of benefits with no responsibility to pay.

Economics policy recommendation from public goods and externality literature

Traditional welfare economics believe when there is a divergence between private and social costs, the market fails and the government should intervene (Pigou, 1920). Following this line of logic, Meade (1952) proposes an imaginary example of a reciprocal externality problem – apples and bees. A bee-keeper gets benefits from her bees feeding on an apple blossom without compensating the apple farmer. At the same time the reciprocal situation is that the bees fertilize the apples, and the apple farmer does not compensate the beekeeper. Meade recommends imposing subsidies and taxes by government. The "apples and bees" example along with Pigou's polluting factory and Mill (1848) and Sidgwick (1883)'s lighthouse illustrate the "externality" phenomena where government action is invited to rescue "market failure".

Blaming the market's inability to take externality into account, ideal Pigovian taxes are proposed to reduce market failure. The amount of Pigovian taxes levied is set equal to the negative externality, and the amount of Pigovian subsidy imposed is set equal to the positive externality.

Based on Cornes and Sandler's work "Theory of externalities, public goods, and club goods" (1986), it is plausible for the government to intervene to provide a service if the service uses public goods and has the prospect of generating substantial positive externality.

New Institutional Economics

New Institutional Economics (NIE) originates from Coase (1937)'s fundamental insight of transaction cost. NIE emphasis the role of transaction cost in determining the institutional arrangements and the performance of different economic structures. Because of the corresponding transaction costs, some organizational choices are more efficient than others (Williamson, 2000; Cheung, 2002).

Property rights

Knight (1924) points out the fallacies in Pigou's interpretation of the divergence between private and social costs. Knight explains that it is not negative externality leading to market failure. Instead, the problem is that there is no private ownership of the concerned resources. Establishing a private property right system will achieve the same economic efficiency as an ideal government intervention.

Coase (1959) in his study of "Federal Communications Commission" contends that "the delineation of rights is an essential prelude of market transactions." Coase questions the entrenched belief that the resource of a publicly owned radio spectrum should be allocated by government's visible hand. Coase proposes that a market mechanism with a clearly defined private property right may better serve the public interest by moving the resource to the hand that values the resource most. Moreover, Coase (1959) shows that under the assumption of zero transaction cost, with the private property right system, market exchange can direct resource allocation to reach the Pareto optimal condition with voluntary negotiation among related parties, if they behave rationally.

In the paper "The Problem of Social Cost," Coase (1960) exposits the reciprocal nature of the social cost problem. The Coase theorem shows that surprisingly, under the same above assumptions, the matter of who has the property right over the resource does not affect the final optimal resource allocation. This is the famous Invariance Theorem.

So the root causes of "market failure" and "externality" are the absence of exclusive property right, the lack of rights to make contracts, or the incompleteness of the contract due to high transaction costs (Cheung, 1970).

Demsetz's view on public goods

Demsetz (1970) shows that when a nonpayer of public goods can be excluded, private producers can efficiently produce public goods. When the costs of exclusion are very high, there are some devices to further private production of such "collective goods." The private provider may tie in the consumption of a second product with the consumption of the collective goods. Because it is possible to exclude the second product, the private provider may have the incentive to produce the tie-in goods. Commercial advertisers and manufacturers of radio and television could tie in the commercial ads with the public goods of broadcasting (Demsetz, 1970).

Transaction costs

Market mechanism and the firm's visible hand are different ways to organize production and allocate resources (Coase, 1937). There are costs associated with the exchange of goods on the marketplace and the maintenance of control over the use of resources even without transaction (Demsetz, 1964). The Pigouan tradition compares the actual market arrangement when there is "externality" with imaginary ideal government intervention. This kind of comparison commits the "grass is greener" fallacy (Demsetz, 1969). The relevant comparison of institutional arrangement is between transactions costs of actual market mechanism and transactions costs of realizable government intervention, given the same effects of an action (Cheung, 1970). One has to consider the costs associated with institutions before reaching the final decision on the institutional choice. (Coase, 1960).

The ideal Pigovian tax or subsidy only exist in the imaginary world. In reality, there are enormous information cost problems in determining the optimal level of the ideal Pigovian tax or subsidy. Identifying, measuring externality, and enforcing Pigovian tax or subsidy present substantial difficulty to the government. The resources spent on correcting positive externality may well cost more than their intended gains.

THEORETICAL APPLICATIONS ON MWN

After presenting the economic theories from both sides, in this section we apply critical theoretical reasoning to the MWN problem. We challenge the welfare economics' policy recommendation of government intervention. Utilizing the tools of property rights and transaction costs, we conjecture the institutional arrangements of MWN production. We deduct a proposition that city government can contract with private firms in providing MWN.

"Public goods" and "positive externality" doctrine

From the "public goods" and "positive externality" doctrine, MWN utilizes the publicly owned radio spectrum and city owned streetlights, which are considered public goods. Moreover, the MWN services are public goods and the corresponding significant positive externality may dictate it is in the best interest of the public to let city government intervene and provide the MWN services.

Lenses of New Institutional Economics

Our critique of MWN as "public goods"

MWN will employ the publicly owned radio spectrum. Radio spectrum is not a public good because it has the properties of rivalry and excludability. Within a certain geographical range, two individuals using the same radio frequency will interfere with each other. In fact, this is the exact reason the Federal Communications Commission's precursor—the Federal Radio Commission--was instituted: to regulate the frequency and establish the order in radio airwave (Coase, 1959). The publicly owned radio frequency can be licensed to a private party through auction. The highest bidder acquires certain property rights over the licensed frequency (McGuigan, Moyer and Harris, 2005). Thus the licensee is protected under the law. If a third party violates the licensee's right over the frequency, the licensee can seek legal action against the offender in the court. Thus, the publicly owned radio spectrum is not a public good, and it can be exchanged on the market.

MWN services are not public goods. Just like other broadband Internet access services, the service is excludable for non-payers. The right to access MWN can be technically protected with an account and password. Without an account and password, a non-payer cannot access MWN.

City owned street lights are relatively more close to "public goods" in nature, since they are both non-rivalry and non-excludable property. City governments finance the street lights services through levying taxes.

Like online database information, MWN services can be non-rivalry when there are no crowding effects (West, 2000). Because technically MWN service is excludable to non-payers and it has non-rivalry property, it is a club good (Cornes and Sandler, 1986). Thus, it can be provided by a private firm.

Our critique of MWN's positive externality

Laissez-faire economists such as Milton Friedman and Friedrich von Hayek talk about externalities as "neighborhood effects" or "spillovers." Positive extremity is a "free lunch" at no cost to the unintended beneficiary (http://en.wikipedia.org/wiki/Externality, 2006).

According to NIE, positive externality exists because the property rights are poorly defined or the transaction costs are too high (Cheung, 2002). The transactions costs in the context of MWN include costs of identifying who are the "free riders", measuring the magnitude of the "side effects" and enforcing the property rights by collecting money form the "free riders".

We model the provision, operation, and maintenance of Municipal Wireless Networks as a standard production process. City government can provide property rights over radio frequency and streetlights in MWN production. Private firms can rent the city properties and combine the firm's capitals, labors, knowledge, and expertise in MWN productions. Owning property rights for radio frequency and streetlights does not mean the city government has to be the MWN owner because the government can surrender a delimited set of usage rights over its property to the private firm, while still keeps the excludability rights. Such separation of excludability rights from usability rights is shown as possible in IT outsourcing contracts (Walden, 2005).

If the property rights of MWN contributors are clearly defined and accounted for when sharing revenues, there will be no positive externality. The benefits they get are just a return on investments and rents. The possible positive externality will be appropriated by the existing local community, who are not payers of MWN services and do not contribute to the MWN production. They may get the spillover benefits because the city now attracts more business and residents. To correct positive externality, transaction costs and information costs may be too high for the government to intervene.

Without government's intervention, there might be some private solutions. Free market can operate in a sub-optimal state rather than ideal efficient market (West, 2000). Some innovative institutional arrangements will reduce transaction costs and mitigate the market failure.

Therefore, based on the above analysis from NIE's perspective, we have deducted the following proposition:

Proposition 1: *City governments will contract with private firms in MWN production. Private firms will own, finance, operate, and maintain the MWNs. City governments will not subsidize MWNs with public funds.*

This proposition implies that in the real world:

- We expect to observe private firms will acquire the usage rights of city owned radio spectrum and streetlights.
- We expect to observe city governments will receive rents from private firms by letting them use the city's property.
- We expect to observe city governments will not use public funds to finance MWN. More specifically we expect the city governments will not finance MWN from public funds--either taxes or newly issued city government MWN bonds.
- Moreover, we expect to find private firms that build, operate and maintain the MWN.
- We will not expect to see city governments use public funds to purchase Wi-Fi equipments, such as wireless routers, wireless broadcasting tower, antenna, transmitters, and access points.
- We will not expect to see city governments use public funds to hire Wi-Fi specialists.
- If a city government chooses to let the private sector provide MWN services, we will not expect to see net cash flowing out of city government for MWN, and we will expect to see some revenue coming into city government from MWN project.
- We expect to see city government detach the usage rights of city property from the exclusive rights. More specifically we expect the city governments allow a private firm to rent city's property, but not make the deal exclusive in the MWN production.

EMPIRICAL CASE STUDIES

To test our proposition conjectured in the last section, we conducted multi-case studies. We collected secondary data from the following Internet websites:

- http://www.usatoday.com/tech/front.htm USA Today
- http://knowledge.wpcarey.asu.edu/ ASU Knowledge W. P. Carey
- http://www.eweek.com/ eWeek
- http://www.jsonline.com/ Milwaukee Journal Sentinel

We have monitored the above websites since 2003. We collected and stored any articles related to Wi-Fi and community based broadband network in a digital repository. Then we performed content analysis against these collected articles. We paid special attention to the articles reporting MWN initiatives. We examined those articles carefully with the economic theories in mind. We investigated the business models, contractual arrangements, and organization forms of these MWN initiatives.

We chose the following cases to report here because they have relatively complete coverage of the artifacts of our interest. We will discuss the cases in regard to NIE theory and test our proposition against these facts.

Case 1: Philadelphia, PA

The city of Philadelphia established a partnership with Earthlink and created a nonprofit corporation, Wireless Philadelphia. Earthlink finances the MWN's infrastructure. Earthlink officially owns the network, thus exempting the city from the state bill banning MWN. The access points or receivers will be installed on city-owned streetlights. The monthly subscription fee for users is $20, while $10 for lower-income household. It will charge about $50 to $60 per month for premium business service with higher speeds. The Wi-Fi services will cover 135 square miles. Tropos Networks is the company in charge of Wi-Fi hardware in the deployment. Moreover the MWN will secure a licensed radio frequency in the airwave. The MWN will save the city government $2 million in Internet access fee now being paid to a commercial ISP, according to the CIO of Philidaphia, PA (Epstein, 2005; http://knowledge.wpcarey.asu.edu/index.cfm?fa=printArticle&ID=1167, 2006; Mandviwalla and Jain, 2006; Nobel, 2006).

Case 2: Tempe, AZ

The city of Tempe relies on a private firm, NeoReach Wireless, a subsidiary of broadband provider MobilePro Corp., to deploy and maintain the WAZTempe network. NeoReach owns the MWN and has signed a five-year definitive agreement with the city. The city of Tempe then selects Strix Systems Inc., a player in the wireless mesh market, to provide the network's underlying technology. The monthly subscription fee for users is $30. The MWN services will be freely available to city departments and available to the local residents and businesses at a reduced subscription fee. The WAZTempe network will cover 40 square miles (Johnson, 2005; http://knowledge.wpcarey.asu.edu/index.cfm?fa=printArticle&ID=1183, 2006; http://waztempe.com/, 2006).

Case 3: Cerritos, California

Wi-Fi start-up Aiirmesh financed, built, and owns the MWN covering the whole city, more than 8 squares miles. The city officials helped in the MWN project. Cerritos allowed Aiirmesh to have access to the city owned facilities such as buildings, traffic lights, and streetlights, so Aiirmesh could place antennas on these properties. Moreover, Aiirmesh can use the electricity power at those sites. The MWN charges users $30 per month to access the entire Internet, while viewing city websites is free. Cerritos agreed to buy 60 subscriptions to the service for its city workers. Cerritos is open to other competing firms to provide Wi-Fi services by allowing them to place their antennas on Cerritos's traffic lights and buildings. Cerritos wants Aiirmesh to makes money because if Aiirmesh does not profit, it will pull out and leave Cerritos without Internet access (Kessler, 2004).

Case 4: Milwaukee, WI

The city of Milwaukee and Midwest Fiber Networks reached an agreement to create a $20 million MWN at no cost to its taxpayers. EarthLink, among others, will be the anchor ISP on the MWN. Users of the MWN will pay $20 monthly fee for complete access to the Internet. However, access to 60 city selected websites on the MWN is free. Milwaukee will allow Midwest Fiber Networks to use the city-owned underground conduit system to run fiber-optic cables and use streetlights to deploy antennas. Midwest Fiber Networks will build the infrastructure and run the system. Midwest Fiber Networks will make a one time payment of $150,000 to the city's "digital divide" fund. The city will get 400 free MWN accounts worth $100,000 a year and 60 city selected websites worth $300,000 a year. Moreover, the city will receive 1% gross revenue from years four to year six, and 3% in years seven to fourteen. Because the future annual payment is a share of the total revenue, the city hopes the MWN is successful and makes more money. The agreement lasts for 14 years with an option to continue for another six years. Both parties can revisit details every three years and a mediator will deal with any future disputes. The city reserves the right to allow other firms to create their own systems on similar terms with the city. Moreover, Midwest Fiber Networks's system will be open to other firms, not just EarthLink, to provide services to subscribers (Borowski, 2006).

Case 5: Waukesha, WI

The city of Waukesha entered into discussion with Cellnet Technology Inc. of Alpharetta, Ga. about MWN. The potential deal will not cost taxpayers money. The city could earn money on the deal by letting Cellnet lease space on streetlights and other local government property. Like Milwaukee's deal with Midwest Fiber Networks, Cellnet will not provide Internet access to the users but will create a network through which ISPs can operate. Cellnet's deal is not exclusive because the city does not want to limit itself to just one vendor (Epstein, 2006).

City, State	Use taxes ?	Owner	Deploy maintain	City input property	Monthly user fee	City benefits	Non-exclusive deal?	Size square miles
Philadelphia, PA	No	Broadband provider	Wi-Fi firm	streetlights, licensed frequency	$20	save $2 million	N/A	135
Tempe, AZ	No	Broadband provider	Broadband provider	N/A	$30	free city department accounts and city websites	N/A	40
Cerritos, California	No	Wi-Fi firm	Wi-Fi firm	streetlights, buildings, traffic lights	$30	free city websites but buy 60 accounts	Yes	8
Milwaukee, WI	No	Wi-Fi firm	Wi-Fi firm	conduit system, streetlights	$20	400 free account and 60 free websites, annual payments	Yes	N/A
Waukesha, WI	No	Wi-Fi firm	Wi-Fi firm	streetlights	N/A	could earn money	Yes	N/A

Table 1. Summary of Findings

Discussion

From the above five cases, we observe some consistent themes. All city governments contract with private firms in providing MWN services. None of the cities own or finance the MWN with taxes. We do not find any city that issues bonds to finance the MWN project. None of the cities build and operate the MWN. Private firms own, finance, deploy, and manage all the MWNs. We find city governments collaborate with private businesses by forming partnerships or jointly creating non-profit organizations. Most MWNs' service plans include a monthly subscription fee that varies based on the level of services. We observe most cities contribute to the MWN projects by surrendering the usage property rights over their streetlights, radio frequency, buildings, and other facilities to the private firms. In return, the city governments get benefits of free MWN accounts, city selected websites available free on MWN, savings on ISP fees, and even future annual share of gross avenue. We find some cities explicitly reserve the rights to contract with other firms in the future, so the deals are not exclusive. Overall these findings confirm our proposition and its implications.

Moreover, we discover some interesting facts from the above cases. Some city governments explicitly express the wish that the private firms can make more money in MWN services. The rationales for the city governments are:

- In the case of sharing future gross revenue, the bigger the total revenue, the more money the government can receive.
- In the case of a small city, if the private MWN firm cannot earn a profit, the firm will pull out of the region and leave the city without Internet access.

On the other hand, some city governments do bargain aggressively with private firms on contract terms to get as much as they can.

In most cases, we see more than one private firm involved in the provision of MWN. Usually a broadband provider and a Wi-Fi technical firm work together. Moreover, more than one ISP provides access services over the MWN platform to the end users.

CONCLUSIONS, LIMITATION, AND FUTURE WORK

Overall, our empirical study supports our proposition. We conclude that most city governments can contribute their property rights over city owned streetlights, buildings, and publicly owned radio frequency to the production of MWN. Furthermore, no public funds–either taxes or issued bonds--are found in all the cases. Most MWN are deployed and maintained by private firms, either broadband provider or Wi-Fi firms. Taking these evidences together with the theoretical prediction of NIE, we tend to conclude that city government does not need to finance, build, and maintain MWN. Instead, it can contribute to MWN by donating its property rights and work with the private firms. In the best interest of the public, city governments do not need to intervene in the production of MWN, neither by the city government itself producing MWN nor by imposing a subsidy to private firms.

In sum, the NIE theory generates helpful explanations of the business model, contractual arrangement, and organization structure choice for MWN.

The primary limitation of this paper is that we only relied on limited secondary data. By extending this study and examining more samples and tracking them over time, we may further test the findings and generalize our conclusion. On the theoretical front, we may extend this research by considering other constructs that may influence the institutional arraignments of MWN. These factors may include: MWN governance structure, contract issues, social costs, collective actions, commons (Damsgaard, Parikh and Rao, 2006), and corruptions.

Although above five empirical cases support NIE prediction, our ongoing research does come across a counter example. A local community utilizes public funds to build MWN, when no private firm wants to help. Rural Nevada, Mo. spent $20,000 to build a MWN, covering 8 squares miles, and it costs residents about $30 per month (Kessler, 2004). We acknowledge there might be situations that it is more efficient to let the city government provide MWN. Maybe the scale of economy and demand of MWN services play some roles in attracting private firms to invest in MWN. However, before further empirical study, this is only our conjecture. Moreover, we find some cities provide free MWN services with limited scope and degree (Miller, 2003). We also find some grassroots MWN movement initiatives in which individuals collaborate with each other to form collective actions to advance their ideology and cause (Moore, 2005; Schmidt and Townsend, 2003; http://mobile.ithub.com/blogs/mobile/archive/2006/02/02/5480.aspx, 2006). Will these emerging trends be just marginally relevant or are they equally important as a MWN institutional arrangement co-existing with the ones presented in the paper? It seems future empirical research on MWN institutional arrangement will be fruitful in both extending our theoretical understanding of NIE in the context of MWN, and generating useful policy recommendations to city governments and city CIOs.

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