



# A profile of visual analytical toolkits for understanding the spatio-temporal evolution of broadband provision



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## ABSTRACT

Problems with currently available broadband data sources highlight the pressing need for novel data analytical methods and tools that enable policy makers to explore broadband market dynamics. Given this pressing need, the goal of this paper is to discuss the current state-of-the-art in geovisual analytic tools that could be applied to broadband analysis and demonstrate how these toolkits may be applied to answer important policy questions about the spatio-temporal evolution of broadband markets.

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## 1. Introduction

Due to the unparalleled reliance of people and businesses on Internet-enabled technologies, the private sector and government continue to expend an enormous amount of time, energy, and money on rolling out Internet infrastructure to consumers. These efforts include national policy initiatives to promote competition amongst private telecommunications carriers via the Telecommunications Act of 1996 (TA, 1996), and more recent efforts to promote competition, and affordable, quality broadband access in the National Broadband Plan (FCC, 2010a). The increasing reliance of businesses and individuals on information technology, including broadband, and disparities in access to this critical infrastructure, has prompted widespread scientific inquiry into the nature and sources of the *digital divide*, which is a phrase that describes uneven access to information technology (IT). Results of research on the spatial aspects of the digital divide find disparities in availability related to demographics, socio-economic status, and educational attainment (Chakraborty & Bosman, 2005; Gabel & Kwan, 2001; Grubestic, 2004; Grubestic & Murray, 2004; Hoffman & Novak, 1999; LaRose, Gregg, Strover, Straubhaar, & Carpenter, 2007; Mossberger, Tolbert, & McNeal, 2006; Norris, 2001).

In addition to these disparities in access, the National Broadband Plan also highlights the need to improve the quality of service by which people and businesses access broadband. At their core, these service issues exemplify the multifaceted nature of the digital divide (Grubestic, in press) and a pressing national need to understand how these disparities impact a variety of research and policy domains including energy, government, education, healthcare, businesses, and economic development. Presently, this is an extremely challenging task given the current data environment. The only publicly available datasets for research and policymaking purposes are from the Federal Communications Commission (FCC) (FCC, 2010a, 2010b) and the National Telecommunications and Information Administration (NTIA) (NTIA, 2014). More recently, data from private sources, such as Ookla (2013), have become available. However, these sources do not contain historical data, which makes the retrospective analysis of the digital divide and its evolving impact impossible.

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Problems with currently available broadband data sources highlight the pressing need for novel data analytical methods and tools that enable policy makers to explore broadband market dynamics. The need for innovative and interactive spatiotemporal analytical tools is not only critical to understanding the multi-faceted impacts of the digital divide, but the evolution of this divide through space and time. Given this pressing need, the goal of this paper is to discuss the current state-of-the-art in geovisual analytic tools that could be applied to broadband analysis and demonstrate how these toolkits may be applied to answer important policy questions about the spatio-temporal evolution of broadband markets.

The remainder of this paper is organized as follows. [Section 2](#) will discuss the data currently available for policy analysis, which is particularly important for understanding the value of visual analytics tools. [Section 3](#) gives a broad overview of applications of geovisual analytic tools in telecommunications. This includes a discussion of their use in visualizing and analyzing broadband data. [Section 4](#) demonstrates applications of visual analytics toolkits in the context of policy analysis. Finally, the paper will conclude with thoughts on a research agenda for the applications of these tools for policy analysis.

## 2. Overview of available broadband data

One of the reasons for the inability of researchers and policymakers to understand the evolution of the digital divide through space and time is the dearth of a consistent public time series dataset ([Greenstein, 2007](#)). This relative lack of publicly available data is related to the proprietary nature of information about private broadband providers. It is also related to changes in reporting requirements at the federal level ([Greenstein, 2007](#)). Over the years, the recognition of broadband as a foundational component to competitiveness has stimulated demand for data that could be used to analyze this critical component to economic vitality ([Greenstein, 2007](#)). This demand by the research community and policymakers has improved data availability as key agencies in the broadband arena, such as the Federal Communications Commission (FCC) and the National Telecommunications and Administration (NTIA), have stepped up efforts to collect and disseminate critical information about broadband availability. Due to these efforts, researchers now have a wider swathe of historical and current data sources to access as they seek to uncover the underlying processes responsible for the current distribution of broadband.

The demand for better data with which to analyze broadband availability and the dynamic nature of the digital divide has evolved steadily since the FCC began collecting and reporting data via their Form 477 database in 1999. Prior to the release of these data, it was not uncommon for researchers to use proxies for information and telecommunications infrastructure (ICT) such as bandwidth capacity ([Hackler, 2003](#)) and the number of information intensive businesses ([Sohn, 2004](#)). Today, researchers have two sources of publicly available data to access for research purposes, the Federal Communications Commission (FCC) database and the National Telecommunications and Information Administration (NTIA).

### 2.1. Federal Communications Commission (FCC) data

Since 1999 until recently, the FCC's Form 477 database has been the only source of publicly available information about broadband provision. This is due to the proprietary nature of information associated with the telecommunications industry ([Greenstein, 2007](#)). Data available from the FCC represent an interrupted time series that is broken up into three pieces 1999–2004, 2005–2008, and 2009 to the present. The time series breaks in these data are due to a series of reporting changes which include variations in the spatial scale that data are reported. These breaks make longitudinal and panel analyses difficult if not nearly impossible. Before such analyses could be done, it would require rectifying the reporting changes highlighted below.

Data for the 1999–2004 time periods were collected from private providers with 250 high-speed lines or more in a given state and aggregated in the form of provider counts to the ZIP code area level. Thus, these data are a measure of broadband availability in ZIP code areas. One issue with these data is that ZIP code areas with counts of fewer than four providers are suppressed to protect the identity of private providers in these areas. Prior studies have interpolated these missing data by assigning a value of one provider to ZIP codes with suppressed information ([Grubestic, 2006](#); [Grubestic & Murray, 2002, 2004](#)).

Information from Form 477 database for the 2005–2008 study periods is also reported at the ZIP code area level. There is one major difference between these data and the data from the prior period however. Information was collected from all providers, not just those with 250 high-speed lines or more. This change creates a discontinuity with the 1999–2004 time series database however because it likely inflates provider counts as a result of including more providers in the data collection process.

From December 2008 to the present, information is reported at the census tract level<sup>1</sup> rather than the ZIP code area level. This change in spatial units at which the data are reported presents a second discontinuity in the FCC data. For the first time as well, speed-tier information is now included in these data.

<sup>1</sup> Information is reported using 2000 tracts boundaries.

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