

“We call it Hi-Fi”: Exposing Indian Households to High Speed Broadband Wireless Internet

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ABSTRACT

As access to the Internet improves globally, we argue that speed is important for accelerated and full-fledged exploration of the Internet. We provided high-speed broadband service plans and Wi-Fi access points to 12 Internet-using Indian households in Delhi and Lucknow for three months. We sought to understand uptake, trajectories, behaviours, and developmental impact of the speed of the Internet on the daily lives of our respondents through a multi-phased study (baseline, *in-situ* usage, follow-up). Our findings suggest that high-speed Wi-Fi led to 2-3x increase in online activity and higher-bandwidth activities; spurred Internet skilling and instrumental uses online; shifted the time and space of device access; created social currency; and transformed the construct of Internet for the households. Ultimately, 8 out of the 12 households switched to high-speed Wi-Fi after the study concluded. We discuss considerations for policy and infrastructure deployments in introducing and onboarding new and existing users living with slow speeds to higher-quality networks.

Categories and Subject Descriptors

H.1.2 [User/Machine Systems]: Human Factors

General Terms

Human factors

Keywords

India, Internet, high speeds, Wi-Fi, broadband, longitudinal study, ethnographic study, digital habituation, infrastructure

1. INTRODUCTION

Internet access is rapidly expanding in developing countries [20, 21] and has become a key element of international development agendas (see, e.g., [53, 59]). Although most research on Internet impact is still focused on developed countries (and impact statistics are always suspect), broadband Internet access in developing countries has been linked to economic growth and productivity gains using macroeconomic data (see, e.g., reviews in [23, 59]); household income growth using microeconomic data (e.g., [41]); and various individual benefits such as improved healthcare and e-government (see, e.g., overviews in [59]).

Much attention in ICTD is focused on appropriate access

technology for lower socio-economic strata (e.g., low-bandwidth systems and services), but we believe that user pathways to broadband adoption and the impact of broadband on social and economic development should be examined as well. Analytic constructs around adoption and usage that manifest in the early adopters of the lower-middle- and middle-classes have proven useful in many contexts. Miller and Slater’s ethnography of fixed Internet use by such populations in Trinidad [29] has over 1,000 citations. In the computing literature, observations about deliberate Internet usage patterns among Nairobi working professionals [60] have been fruitfully applied in design contexts ranging from marginalized youth in Cape Town [35] to low-income rural/urban Kenyan households [32].

We call attention to how broadband users perceive *speed* and how they come to understand higher-speed service plans. Actual broadband speeds are particularly problematic in India, at least as indicated by 2015 data. While TRAI estimated that 19 million Indian households subscribed to fixed broadband [52], Akamai measured a mean Indian broadband connection speed of 2 Mbps (the slowest in their Asia-Pacific panel) and showed only 6.9% adoption of 4+ Mbps service [1]. 3G mobile “broadband” does not help in this regard. While popular (industry estimates of 30-day Internet usage, including mobile, were as high as 375 million [18]), a recent national survey showed that 48% of urban respondents were not able to distinguish between their 2G and 3G speeds and saw no reason to use 3G given the added expense [10].

In this paper, we highlight key challenges for governments and institutions hoping to benefit their populations through increased broadband adoption: emerging Internet users may not have experienced high speeds, which lead them to discount the benefits of a faster Internet plan relative to the hazards, in terms of finances and convenience, of switching. Direct experiential access is an important barrier to adoption—even when economic and technical capacities are not.

Our approach was to expose households to a near-future technology [43] of high speeds to understand resistance, learning, adoption, and adaptation. Home broadband speeds matter because they influence how users access the full range of *interactive* Internet services and applications, including media streaming, online commerce, content creation, audio/video communication, and even information search. Venkatesh *et al.* note that the home is the contact zone, a site for productive and family life, where rapid technological innovation and change play out [54].

Twelve Indian families in Delhi and Lucknow, who were already Internet users, were provided with the highest-speed Internet plans available in their neighbourhoods and a Wi-Fi access point for three months. We conducted fieldwork to understand how the Internet and speeds were perceived, analytically and emotionally

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understood, and interacted with: before, during and after high-speed access.

Our paper contributes to ICTD by (1) highlighting the developmental impact of higher-quality Internet and its integration into domestic life. Specifically, we highlight the *processes* of integration: how is the high-speed connection brought in, how does it get situated in the home, how do the members learn to use it, how is it symbolically presented to insiders and outsiders, and what does it affect online and offline. (2) We identify challenges and implications for introducing new or upgraded infrastructures to emerging Internet users. Irrespective of one's own views on the usefulness of higher-speed broadband, it is being promoted and being adopted (or not); description and analysis of these processes is clearly relevant to development, in the sense of increasing our understanding of technology adoption in developing regions.

In the remainder of this paper, we introduce the people we met and their practices and expectations from the Internet on prior low speed connections. We then describe the themes that emerged from high speed and wireless Internet access, including changes in Internet activity and time spent online; fostering new skills and instrumental uses online; impact of wireless connectivity on portability of devices and social currency; and social agents that accelerated the path to discovery. We share two areas for consideration for ICTD around introducing new infrastructures and motivating upgrades to infrastructures.

2. RELATED WORK

Given the widely-held belief that broadband can facilitate development (e.g., [59]) it is no surprise that there is considerable research on both broadband Internet adoption and Internet usage in developing countries (generally). This research varies in its applicability—broadband is not universally defined, as thresholds increase over time and vary based on local regulatory decisions [4]. (In India, TRAI defines broadband speed as 512 kbps [51]; in the USA, the FCC defines it as 25 Mbps [11].)

2.1 Adoption of (or upgrading to) broadband

Much effort has gone into analyzing broadband adoption in terms of consumer decision factors, with the goal of identifying the most important factors for a particular market. Some recent examples in the IS/MIS field for developing countries, reviewed in [26] (including India [26] and Pakistan [9]) show no factors shared across all of them, in spite of being extensions of a common model [55]. As such it is difficult to take away a general message. Research in this area tends to be focused on network performance or economic impact.

More relevant here is research that explicitly analyses broadband adoption as a sociotechnical process. From Rogers' work on diffusion of innovations [40] we can borrow the ideas that pre-adoption knowledge about costs, risks and relative advantage spread via interpersonal communication, and that factors such as *observability* (learning from earlier adopters) and *trialability* (first-hand learning without commitment) can make adoption decisions easier. From ethnographic research on material culture, notably Silverstone's work on domestication [47], we can borrow the ideas of meaning-making during *appropriation* (entry into the home), *incorporation* (fitting into household routine) and *conversion* (symbolic display outside of the home) of new technologies into the home sphere.

Studies of behavioral change during the process of *upgrading* Internet connections remain quite rare. U.S. studies of individual

households upgrading from dial-up to broadband indicated that broadband facilitated heavier usage, richer media consumption, and more applications [15, 16]. In the ICTD literature, a recent study of a community network backhaul upgrade in Zambia [62] documented an adaptation process in which users explored previously-impossible types of usage and learned (as indicated by network measurements over several months) which were viable with their faster, but still overloaded, backhaul link and which were not. That improved speeds lead to more frequent, bandwidth-heavy or time spent online is to be expected. We contribute by offering a lens into how households starting with constrained, dial-up like conditions learned to live with high speeds, and identifying perceptions, uses and behaviors arising from the new conditions. Of note here is that the households in the study could afford to upgrade speeds—we highlight barriers to infrastructural upgrades and, as we will see later, reasons for or against upgrading infrastructures after experiential access.

2.2 Internet usage in ICTD

The ICTD community has a rich body of work on introducing or understanding Internet encounters in developing countries. We cannot hope to survey it fully, but focus instead on a few key themes that related to the research here.

One major line of ICTD research has focused on technology interventions, typically for lower-income communities. A small sample of Internet deployment models include community telecenter and kiosk projects in rural areas (critically surveyed in [50]); off-duty PC access for service employees in urban offices (e.g., Kelsa+ [38]); and “minimally intrusive” PC access in low-income communities (e.g., Hole-in-the-Wall [30]). The middle classes are generally perceived as being served by the market and less in need of intervention research.

Another major line of ICTD research consists of studies of everyday Internet access, typically with an emphasis on the ways in which users manage economic and infrastructural issues in their environment. A few phenomena of relevance here include the careful pre-planning of sparse fixed-line Internet infrastructure [60]; households' struggles to manage their collective fixed-line usage caps [5]; and the creative and resourceful strategies and skill development employed by urban youth in the process of consuming entertainment content [37], including side-loading and off-line transfer of data [44]. Also of interest here are papers on PC adoption in rural and urban Indian households, observing the aspirational nature of computer adoption prior to the availability of home broadband or dial-up service to the middle class [34, 36].

Our research contributes to the ICTD literature by understanding how existing Internet users in India make meaning out of higher speeds, adapt and modify their behaviours around them, and the developmental benefits that they engender.

3. METHODOLOGY

The study focused on households drawn from the Indian urban middle class. We are particularly interested in this group because, as noted above, access to computing technology is broadly associated with middle-class identity [34, 36]; this identity is constituted through a complex set of performative activities that draw upon occupation, education and consumption patterns [6]. Even lagging adopters of broadband among the rising middle class segment will be earlier adopters than most of India, auguring opportunities for other groups.

While income distribution is highly skewed in India, the middle class is distinct from the urban elites [6]. Two recent reports,

Table 1. Delhi and Lucknow demographics.

	Delhi	Lucknow
Population, city (M) [19]	16.7	4.6
Teledensity, state [52]	238	61
Below poverty line, state [39]	13%	41%

Table 2. Participating households.

#	focus member	size	income	attributes
L1	Sohail (46, M)	4	lower-middle	Car sales owner Netbook, 2 smart phones
L2	Sonesh (26, M)	5	middle	Pharmaceuticals employee PC, tablet, 2 smart phones
L3	Azam (40, M)	7	middle	Real estate agent Laptop, 2 smart phones
L4	Chintan (24, M)	7	lower-middle	SMB employee PC, 4 smart phones
L5	Javed (32, M)	10	middle	Dentist Laptop, 2 smart phones
L6	Hitesh (25, M)	2	lower-middle	Undergraduate student Laptop, 1 smart phone
D1	Sonam (30, F)	7	middle	HR manager Laptop, 2 tablets, 4 smartphones
D2	Prashant (24, M)	3	lower-middle	Call center employee 3 laptops, 3 feature phones
D3	Joseph (45, M)	4	middle	SMB owner PC, laptop, 4 smart phones
D4	Gaurav (29, M)	4	middle	Mechanical engineer PC, laptop, 2 smart phones
D5	Nagina (34, F)	6	middle	Housewife PC, laptop, 3 smart phones
D6	Sikander (43, M)	4	lower-middle	SMB owner Laptop, tablet, 2 smart phones

**Figure 1. Examples of participant communities.**

drawing on different surveys, estimated the 2009/10 middle class at 5.9% [28] and 12.8% [46] of population. (Even the smaller estimate is nearly 70 M people, which is larger than most countries.)

3.1 Sites and locations

Study participants lived in one of two cities in northern India. Delhi National Capital Region (NCR) is a large urban sprawl, encompassing three states and the national capital, New Delhi. It is home to a wide spectrum of social classes, attracting migrants from neighbouring states, and enjoying benefits of infrastructure and services as the national heartbeat. Lucknow is a tier II city and state capital of Uttar Pradesh. A cosmopolitan city, Lucknow is a hub of multiple cultures and religions and former seat of the Islamic Mughal empire. We chose tier II and I cities to understand how two different urban public infrastructures; economic spheres; religious and cultural communities; and technology penetration levels affect Internet uptake and behaviours.

3.2 Research design

Our research approach involved introducing existing Internet-using households to the highest-speed Internet plans in their neighbourhoods.

Twelve households, six in each city, were chosen to be a part of the study (Table 2). The households lived in various urban and suburban residential neighbourhoods to increase geographical and social diversity (Figure 1). Households varied in income (within the middle-income bracket of USD \$150-600/month), size (2-10), structure (multi-generational families, childless couples, unrelated roommates, families with children), and device ownership (mobile phones among all, with some laptops, tablets and PCs). All households were prior users of home Internet; only two households had Wi-Fi access, one through a wireless USB dongle (Mi-Fi) that also provided their (mobile) Internet.

Through the course of the study, the households kept their previous Internet plans. Our research team provided high-speed broadband service (2-48x faster than baseline, with data caps averaging 15 GB/month) and a Wi-Fi access point for three months. ISPs and data plans varied based on local availability of high-speed service. The high-speed service was terminated after the study, which was explained prior to participation. (Baseline speeds and study speeds are shown in Table 3.) Households were compensated with \$140 USD total in cash for participation.

3.3 Research methods

Our research methodology was ethnographically-inspired; aiming to create a thick description [12] of the households through observations, interviews and design activities. Following Venkatesh et al's approach, we studied the households as constellations of physical, social and technological spaces [54]. Research was conducted in three phases: a baseline phase to characterize prior Internet use, an *in situ* observation phase during the use of high-speed Internet, and a follow-up phase one month after the study.

Baseline: Semi-structured interviews were conducted at participants' homes prior to the introduction of high-speed Wi-Fi. Areas of inquiry included daily household life and routines; device use and ownership; current Internet plans, budgets, workarounds, and practices; current online activities; and expectations from the new speeds. Design activities and prompts were used to map out daily technology use and shared device usage. An Internet task sheet was used to elicit baseline online activities, containing online activities, time spent and primary users. Home technology tours were conducted to observe organic usage of devices and Internet. The entire family was encouraged to attend the interviews to get multiple members' views on roles, responsibilities, and value of the Internet. In addition, we examined electricity and Internet access infrastructure in the home, the physical architecture of the home, and visited the local cable/ISP offices.

Observation: Once the new broadband plans were installed, family members were shown how to connect to the Wi-Fi network and were helped with SSID and password setup. Phone calls were placed at regular intervals to understand usage and support the households through any issues with the Wi-Fi. Internet bills for the new connection were collected to measure gross usage, with participant permission. Three months after the introduction of high-speed broadband Wi-Fi, semi-structured interviews were conducted in participants' homes to understand the impact of broadband. Threads of inquiry from baseline were followed

through the focus informant, in order to understand longitudinal and evolutionary aspects of behaviours, perceptions, and usage of the Internet. Interview topics included learning and getting used to the new broadband Wi-Fi, Internet practices and value, and new practices around Wi-Fi.

Follow-up: One month after the study terminated, we conducted follow-up interviews to understand the lasting and transient effects of high speeds. We focussed on the post-study normative Internet plans, motivations or barriers to change, and lasting behaviours and attitudes.

All interviews were videotaped. (All participant names are pseudonyms.) Interview responses were transcribed, open-coded [49] by the first and second author, compared, and clustered to synthesize themes. Interviews were conducted in Hindi and in English. In many cases, we conducted private interviews with children and women, to provide a space uninhibited by older or male members, especially in more conservative households.

It is important to note some key limitations of our methodology. First, our approach is small-sample and qualitative in nature; it is meant to uncover the processes and behaviours in living with higher-speed Internet, but not be exhaustive or definitive. Second, due to organizational privacy policies, we did not directly monitor network usage. Wi-Fi is a shared resource, and tracking usage logs for the entire household (including children) was not permitted. Monthly usage bills were collected; however, these documents stated financial costs rather than bandwidth consumed. Third, our results are not meant to accurately characterize low-income households because we did not study such households. Our approach was to increase speeds for current broadband users (to isolate the effects of speed and Wi-Fi from those of getting connected for the first time), and we were unable (in the time we had) to locate low-income households with fixed-line access to participate. Finally, while three months of study followed by a follow-up after a month may not seem ‘longitudinal’ in the traditional sense of ICTD approaches like RCTs and monitoring and evaluation studies, the time frame was sufficient for us to understand changes to Internet usage, value proposition and (semi-permanent) changes to subscription plans.

4. BASELINE RESEARCH

In this section, we discuss the usage and perception of the Internet prior to the introduction of high speed Wi-Fi. We discuss how the households imagined and made use of the Internet prior to the study, the barriers to upgrades, and how respondents created workarounds for constrained Internet.

4.1 Baseline plans and expenditures

Many baseline plans approached narrowband (e.g., 2G) speeds (Table 3). Eleven families paid monthly subscription charges, whereas Javed (L5) owned a prepaid wireless dongle. In addition to fixed-line or household dongles, 10 households also had access to mobile data (9 prepaid, 1 postpaid) on their primary phones. However, mobile data was not available at all times—many participants only topped up when there was financial availability or a necessity. Seven households were primarily on 2G data plans, some occasionally switching to 3G for a better experience or as a dual-SIM option.

Households spent 5-30% of their monthly expenses on Internet bills, including both home Internet and mobile data, and household “Internet” cost was viewed as this combination. It was considered to be a “necessary expense” by all households. However, mobile data was often paid as an individual expense,

even in multi-generational families where money was usually pooled for expenses.

4.2 Barriers to upgrade infrastructure

Participating households had remained on the same Internet plans for 3-7 years, ever since they first subscribed to Internet service. Higher-speed plans were now available on the same ISP, and the modems/routers needed to upgrade were widely available in retail electronics shops or as part of ISP offerings. All households were on entry-level Internet plans. Joseph (D3), an SMB owner explains his decision in acquiring a basic plan:

“When I purchased the plan I just wanted to get Internet at home. I just asked for the basic plan from the shop. They showed me a variety. But I said basic will do, thinking we can change if needed. But I have not changed since then.”

Internet plans were not upgraded for several reasons.

First, the incremental utility of high-speed Internet was not entirely clear from their baseline usage patterns. Online activities were centred on light Internet searches, social media and downloading songs, for which basic connectivity seemed sufficient. Few (or no) friends, family members and neighbours had high-speed Internet plans, which limited opportunities to experience such plans directly or access trusted opinions; as such, in Rogers’ terms, high-speed Internet had low observability.

Second, upgraded service was perceived as more appropriate for professionals, whose livelihoods or quality of work depended on it. In the words of Azam (L3), a real estate agent:

“My Internet is slow sometimes and it takes sometimes hours to watch videos or quite long to post selfies. I can manage though. It’s a struggle but it’s working for some things. Faster speed is for IT people, not for an ordinary person like me.”

The idea of lack of relevance extended to Wi-Fi, which was only taken up in two homes even though all households had devices that were Wi-Fi-capable. In fact, some of the families, especially the younger members, already connected to Wi-Fi networks in friends’ homes or in work environments.

Third, change could be costly and difficult to reverse. Contractual commitment to a service that may not have value was a concern. Unlike prepaid mobile data, which allows flexibility to try different data technologies like 2G, 3G and 4G for a short period, postpaid fixed-line Internet requires users to commit to monthly service. Infrastructure upgrades were often viewed as a permanent change to cables and architecture of the home, with a high cost to revert to the older setup if the new one proved worse. In Rogers’ terms, high-speed Internet was seen to have low trialability. Households chose to “make do” with the current balance of cost and speed, as Prashant (D2), a 24-year old call center employee, explains:

“Suppose I change the plan to higher Mbps. If something goes wrong, what will I do? I have heard things can go wrong with billing or I might get same speed [and still pay more]. It will be a hassle to change the plan again, go to the office, stand in line. We can manage with slow speeds.”

Some households noted a hesitation to be one of the first to try a new infrastructure in their neighbourhood, given the higher commitment and costs.

Three households had considered Wi-Fi and higher speeds, but lacked the know-how to know which connection to get. In the

case of Joseph (D3), in the place of a better broadband connection with Wi-Fi (described by him as “terrible”), a USB dongle and mobile data were supplemented because the family knew they were not aware of all of the options from which to choose.

4.3 Strategies to optimize for slow speeds

Households made use of their Internet plans by heavily self-regulating and pre-planning their usage (cf. [5]), to cut costs and make applications and websites work on slow speeds [27, 43]. Disciplined usage was achieved by putting off application updates and restricting application installs to the most relevant or useful apps. Wi-Fi from schools, offices or neighbours was used to update applications. Media content was often downloaded to be viewed without buffering and to avoid paying for data costs in reviewing. Some of the younger users with lower speeds frequently relied on their friends with broadband connections to download media content for them (cf. [44]), which was reciprocated in other ways like buying snacks or sharing notes.

On mobile data, many prepaid users saved 3G for higher quality experiences and relied on 2G primarily. Mobile data was often turned off at nights to save money on data costs, save battery charge, and reduce radiation exposure (Sec. 5.8). Hitesh (L6), a student, explains:

“We try to limit ourselves. If the pack gets over in 15 days, we sacrifice for another 15 days. Then we use 2G. We save the 3G data for emergency purposes only so we can use it as long as possible before recharging.”

5. LIVING WITH HIGH-SPEED WI-FI

In this section we highlight how the effects of living with higher speeds and Wi-Fi on Internet value, expectations, and usage. In terms of the domestication of broadband in the home [47], the first five sub-sections may be thought of as documenting *incorporation* processes—the methods by which the household members learn to make direct use of the technology’s functionality, especially in their shared routines. The latter three sub-sections can be seen as touching on the appropriated technology’s *conversion* into social currency and its *objectification* as part of the moral order of the home.

5.1 Internet value, volume, and activity

While household adoption and appropriation of “the Internet” *per se* was not an issue (each had well-established and routinized behaviours around their baseline Internet), our research showed a marked shift in the amount and type of Internet usage with the new speeds. Living with high-speed Internet at home motivated users to do more things online because the Internet qualitatively felt more responsive and engaging, as reported by the households. The perceived value of the Internet was reported to have increased with a faster and reliable network; in particular, participants noted their time was ‘saved and respected’ with lower latency on websites and applications. As a direct result, time spent online increased, high-bandwidth activities were explored, and a deeper engagement with websites and applications was seen (not dissimilar from [16, 61]). Chintan (L4), an SMB employee, explains:

“Time is being saved. In less time I am able to do more things. The things for which you now use the Internet have become very valuable. Those things are of great value to you. Life becomes easier. You get all information at home only, you don't have to go out and spend so much.”

A typical trajectory as narrated by users involved initially experiencing a marked change in speeds, performing “speed tests,” experimenting with a range of online activities, grasping new information on applications and websites from media and word-of-mouth, and establishing patterns around new Internet activities. Once the new connections were setup, 9/12 households reported performing a speed test to verify the promise. In most households this involved playing YouTube videos or, in a few cases, placing Skype calls with relatives in other states. Smoothly-playing video was perceived as a true measure of high speed. Only two households conducted an online speed test (e.g., Ookla). Once the connections “passed” the tests, trust levels were reported to go up, though few households could recall the actual speeds of their new connections.

Households rapidly engaged with new online activities. Many had initial difficulty figuring what to do on the new speeds; a few sought out suggestions for websites or apps from tech-savvy work colleagues. That the Internet felt ‘responsive’ was noted as the primary reason to try out things online. Previously attempted online activities, abandoned due to taking too long, timeouts, or getting “stuck”, were tried again with the new connection. Sikander (D6) explains his changes:

“We tried to download earlier, but the speed was so irritating. I used to download the wallpapers and it used to consume 1 hour and now it is done in 2 minutes. Earlier we hardly paid attention to all this and now we feel like spending the time. The mandatory tasks were done anyway but now we feel like spending more and more time. We are least bothered now. No tension of speed or anything.”

Time spent online was self-reported to go up 2-3x since the baseline. Users in our study described several instances where they had previously restricted, avoided, or abandoned usage on websites, and noted a phase change in their time spent online. In three households, housewives and senior citizens reported going online more often, with the help of their children (Sec. 5.7).

In addition to more time spent online, high-bandwidth activities were reported to have increased (based on task sheet exercises): users started doing more media downloads, updating applications, exploring and installing new applications, streaming media content, and online searches. Ten households went from putting off app updates as much as possible to getting all apps updated and trying new apps on Play Store every day. Seven households reported that their downloading decreased and streaming increased with multimedia content. Particularly with video streaming, households explored new types of videos such as research and education; moved from short-form to long-form videos; discovered catch-up TV for the first time; and skipped to the most interesting or relevant parts of the videos. Sonesh (L2), a pharmaceutical industry employee, explains:

“Downloading is easy. Emailing is very fast. I keep my phone updated now. I have tried at least 30-40 apps in 3 months, Buffering is not there now. Earlier you had to wait for 5 minutes, then it played, then wait for 5 minutes...and it went on and on. Now you can watch videos regularly...whenever we feel like it. Mahabharath [an Indian TV show] is without buffering. You can easily watch it online. If we miss the episode on TV, we watch it online as soon as it is available. The speed is so good. It's like watching on TV. If we miss a cricket match, then we see the highlights or match.”

New uses for the Internet were explored by visiting rich and productive content on websites and apps and using devices, which were previously under-explored. In particular, search queries were reported to have significantly grown with the new speeds, as the page load times had less latency. New applications were tried out for the first time, such as maps, video chat, job search, photo editing, news, lifestyle, and health applications. Saleema, Javed's (L5) wife, also a dentist, explains:

"Earlier we hardly paid attention to all these new websites like OLX [a classified ads site] and educational videos on YouTube, and now we feel like spending the time. The mandatory tasks were done anyway but now we feel like spending more and more time. We are least bothered now. No tension of speed or anything."

As Rangaswamy and Cutrell note, non-instrumental uses may not show immediate "benefits," but lead to increased agency, play, self-exploration and increased daily technology use [37].

5.2 Instrumental use and skilling online

In our baseline research, we learned that the Internet was primarily used for lightweight communication and entertainment activities. With the new speeds, households expanded their range and volume of these activities. Most households, however, noted a true shift in value of the Internet when they explored productive, informational and instrumental uses online. Internet gained meaning when it aligned with user values of self-expression, livelihood, and self-improvement. Sohail (L1) narrates:

"If speed will not be there, we will be stuck at one place. When I started, I did not have interest in this. But now, I feel like learning. There are many things, which would not even do earlier. I used to think, 'of what use is Internet to us?' But it is not true; we get to learn a lot of things, learn about the world. We also get earning from this. I wish I got the high speeds many years ago. It would have improved my life."

Households explored a variety of information search uses online for the first time. Azam (L3) looked up the state voter's list online before elections, instead of visiting the physical venues. Nagina's (D5) daughter compiled study material for her board exams. Hitesh (L6), a native Hindi speaker, discovered a translation application for Hindi-to-English queries, for terms like 'democracy' and 'women's oppression', to advance professionally to find a better job. He also taught himself basic Java and C to tutor computer science to schoolchildren. Sonam (D1) looked up birthing information for her sister's first pregnancy. While these instances may seem specific, they occurred in concert with a variety of other new explorations of the Internet, for information, entertainment, communication, and instrumental, as noted in other studies of the Internet and mobile phones [8, 17, 37]. As Sonam explains, *"previously we did not feel like trying Search [because of slow speeds], but now the doors have opened and I am enjoying and learning so much."*

Many households booked online train tickets on the notoriously slow Indian Railways priority booking, which stayed open only for a few minutes each morning but timed-out over slow speeds. Indeed, the ticket booking experience was viewed as one of the gauge for connection quality.

Convenience of the Internet was a new dimension by many households. Several informants ordered goods through online shopping for the first time, exploring websites like Flipkart,

Myntra and Snapdeal discovered through TV and newspaper advertising. Nagina (34) describes:

"High speeds have made my life so convenient. I have explored so much in these few months. I feel smarter now!"

We did not observe any new Internet users in the households over the course of the study, but did note some significant shifts in the amount of time that light and fringe users spent on the Internet. Sonesh's (L2) mother learned how to search online from her daughter-in-law. A couple of months into the study, she started her day with religious *bhajans* in the morning on YouTube and played recipe videos while cooking their family-favourite biryani. Aisha, Azam's (L3) wife, from an orthodox Muslim family, would earlier use her smartphone for phone calls and relinquish her phone to her children for games like Angry Birds and ConnectToo. With the new connection, she discovered new uses online with tailoring designs, recipes and chatting with her old school friends.

5.3 Discovery of economic value online

Seven households explored economic value online for the very first time. In addition to the faster speed, the novelty effect of a responsive Internet could well have motivated some users to find new use cases.

First, commerce was conducted online and financial gains were even made online. Several of the households tried online shopping for the first time. Deals and discounts were looked up more frequently than in the baseline by a combination of subscribing to apps and visiting coupon websites. The lower-middle income households of Sohail (L1), Chintan (L4) and Sikander (D6) were particularly active in exploring opportunities to get discounts or make money online. Sohail (L1), a second-hand car salesman, posted ads on OLX for the first time using his son's help. He sold 5 cars in two months.

"Things have changed. I get a better response in business. I don't have to submit paper ads now. I now put up ads on OLX and get faster response. OLX has given 75% success. In 3 months we got to sell 5 cars, which is great! You get opportunity to move forward in life. Now, I am going to start business in new place also, of big cars like Audi and Benz."

Less dramatically, Hitesh (L6), a college student with low cash income, earned phone credit by visiting laaptu.com and ultoo.com and by sending SMS to his friends. In this way he earned Rs. 10 (17 cents) worth of credit every 8-10 days. His baseline Internet use had been largely limited to social media and games. Even these modest discoveries of financial and economic use cases led to a pronounced change in the perception of the Internet for him, making it a "life saver."

Second, a high-speed home network meant that users could save on 2G/3G costs, turning off their prepaid mobile data at home. Nagina (D5), a housewife, cut off her 3G data plan entirely; for times when she went out of the home, she used a 2G plan. She regularly pre-loaded maps for her trips between Noida and Delhi and used the directions offline.

"Obviously I prefer Wi-Fi because it encompasses all the cell phones and even if we pay Rs 1500, it sounds economical. Now I have stopped the 3G net pack [mobile data plan]. I do most of my browsing at home, so when I go out it's only phone calls and SMS and 2G for chatting."

5.4 Shifts in time and space of access

With baseline fixed-line Internet, households reported connecting a stationary computer to the modem/router, often in an inconvenient posture and location. Even portable devices like laptops were also used in this way. With Wi-Fi, the 10 households explored new locations for usage, such as the terrace rooftop, bedroom, kitchen, and the garden—*where* and *when* they wanted to use the Internet.

Saleema (L5's wife) integrated Internet use into her daily activities, such as watching videos while cooking or playing fitness videos while exercising at home. She noted how she searched, paused and played videos as desired, while cooking for the family of 10 and multi-tasking several dishes at once, through multiple tabs of her favorite chef Sanjeev Kapoor.

Wi-Fi altered the spatial structure of access, by mirroring the social flow of the home. Five households reported a shift in their access locations to more social and convenient spots [58]. Sonesh (L2) carried video content to his family members in the living room or the dining table, where they spent maximum time. The family watched catch-up TV episodes of Koffee with Karan on the laptop screen. Sometimes Sonesh took the laptop to the garden to watch content privately (Figure 2).

Prashant (D2) and his roommates had movie nights with friends in their living room; previously they were restricted to a connection in one of the bedrooms, which caused friction with maintaining shared experiences in private spaces. With the new connection:

"If you liked some video and you wanted to show it to everyone, you had to call everyone to come to the room. There's no place to sit and be comfortable. But now I can just open it and show it to everyone. It becomes convenient. It's easier for us to spend time together."

Time of access was also altered, since more devices were connected and freed up. During the study, we observed more frequent accounts of days starting and ending with the Internet through Wi-Fi, which was previously done on 2G.

"You can use it at bed time also, sitting on bed. If you are stressed, you can listen to your song. Earlier, we had to switch on the FM. Now, we can watch live concerts also."

5.5 Liberation of Internet-capable devices

Wi-Fi allowed users to use the Internet on preferred devices and connect Internet-capable, but previously un- or under-connected devices. Simultaneous connections opened up parallel usage sessions, instead of waiting for the shared Internet device, usually the PC, to be freed up. Bigger-screen devices, such as PCs or laptops, became shared devices, used through turn-taking, co-viewing or intermediation (cf. [43]).

Wi-Fi-only tablets suddenly became as useful as smartphones instead of (expensive) music players or gaming devices. John (D3's son), 17, connected his iPod to the Internet for the first



Figure 2. New locations explored with Wi-Fi usage

time, upgrading two releases of iOS and installing new apps. Chintan's (L4) tablet was the shared device for the entire family. Prior to the study, his 2-year-old niece mainly used the tablet for offline gaming apps. Chintan discovered new Internet experiences on his tablet, exploring and updating new applications, with the device quickly becoming his preferred and personal device (no doubt to the dismay of his niece).

"I didn't use any app on my iPod because it required Internet for Facebook and Skype. I used it for music, games and for taking photos. I downloaded Facebook, class materials, Internet radio, YouTube, and stuff like that after I got Wi-Fi. It's very cool."

The most exploratory participants discovered new ways of connecting devices. Prashant (D2), his roommate, and their friends were aspiring young professionals who wanted to join the Indian civil service; each spent a lot of time studying for exams. They had one laptop and a few smart phones, with only the laptop being connected to wired fixed line. Hence, the laptop was the shared device and repository for downloaded content like exam PDFs, music and movies. Due to the expense of 3G phone bundles, Prashant's baseline behaviour was to download content onto the laptop and then transfer it to each phone via Bluetooth. For the study, Prashant's household received a 3G dongle that also functioned as a Wi-Fi hotspot, as there were no high-speed fixed-line options for their apartment. Prashant and his friends were then able to connect their smart phones to the Internet and quickly share downloads over their wireless LAN. Prashant noted that their exam preparation became more efficient with the ability to retrieve content on their personal study devices.

Once Prashant discovered that any USB port could power the dongle and that it did not have to be connected to a computer, they took their residential service plan on the road. His friends connected it to the car cigarette lighter; they visited five states in northern India in their Wi-Fi-enabled car, navigating using online maps for the first time. As an experiment, they even hooked up the dongle to the USB port in a bus, opening up the network for other passengers to use.

"We have this charger plug in DTC [Delhi Transport Corporation] buses near the driver's seat where we plug in the Wi-Fi. We used it in DTC buses and had a good experience. There were four other people who were using it. I noticed when I got down that one guy disconnected it. People got amazed. They might have noticed us doing the activity. We tried it as an experiment. It was damn cool."

5.6 Social currency through Wi-Fi

Some of the households were the first in their vicinity or neighbourhood community to get Wi-Fi, despite the option being available in the market for a few years. This presented opportunities for what Silverstone has described as *conversion* of domestic objects into symbolic activity outside of the home, and what Dickey has described as the performance of Indian middle-class identity through appropriate consumption [6].

In some cases, social currency came from being early adopters. In Lucknow, three (of six) households were the first on their street to get Wi-Fi (which they knew from discussions with neighbours and—in some cases—earlier scans for open Wi-Fi networks on which to freeload). These households gained social currency from high-speed Internet and Wi-Fi. Sonesh's (L2) family felt proud of being the only household to have Wi-Fi in the entire residential

neighbourhood. He invited his cousins home and shared the connection, becoming the local high-speed provider.

“My cousins are on the same street, here only. I invite them home to come and experience this new Wi-Fi. No one in my family has Wi-Fi. They come and do downloads here. I feel proud of it.”

In other cases, a high-speed connection offered the chance to rebalance relationships within an existing network of adopters. Hitesh (L6) was relieved and excited by being able to share files with his friends. As a lower-income college student from a village in Uttar Pradesh, he used to request media files from his friends with more pocket money to economize on his own monthly expenses. With a faster connection, Hitesh started becoming the content hub, taking on-demand requests from his friends and advertising his collection.

“There is a movie, Dark Knight, which I downloaded. This time I gave it to my friends. I used to feel bad about asking my friends to download for me. I feel very good now. My friends commented that, ‘Hitesh bhai, you used to ask before but now you are giving us.’ I already knew how to download as I went to friend’s place that has a broadband connection. I don’t have to worry about being the gawar [uncivilized] with nothing. We call this Internet Hi-Fi [cool and trendy in Indian English] now, it’s fast and makes me confident.”

5.7 Children as catalysts and intermediaries

Children, especially school-aged children, played a critical role in exploring and discovering new uses for the Internet and getting family members to experience along with them. Many of the households were multi-generational “joint families,” with seniors, middle-aged members, and children living under the same roof. Children explored new applications for the Internet based on friends’ recommendations and news media. News channels and papers in India carried regular reviews and advertisements for devices and applications, often with celebrity endorsement. In several households, parents tried new application through their children’s intermediation (cf. [43]).

Children’s use of the Internet was usually monitored. The ease of viewing adult-like content, such as pop-ups, advertisements, videos, and search dropdowns caused concern among many households. Applications were seen as slightly more secure due to fewer pop-ups than webpage ads. For children between 5-10, usage of the Internet was limited to 1-2 hours per day. The Indian system of competitive examinations and emphasis on marks caused severe anxiety among parents to have their children “focus on studies to be successful.”

In four households, the mother’s phone was the shared phone with kids. The father’s phone was typically more high-end (10 households), and was used along with the work laptop (if the male members had one) on weekends by children. In a couple of families, children are given devices over the weekends. Devices were password-protected so children could ask for permission first and “earn Internet time.” Sonam (D1) recharged her children’s phones with small-prepaid top-ups, usually 2G.

“I give them the phone on weekends only. If I give the phone to my son, he will never study. He is into it all the time. He plays a lot of games.”

In all of these ways—facilitating, monitoring, rationing, earning—families enacted a collective process of *objectification* [47], whereby the appropriate consumption [6] of the new broadband

Table 3. Internet plans after the study.
(Mi-Fi = USB 3G hotspot, Wi-Fi = wireless access point)

#	Baseline plan	Study plan	Post-study plan
L1	300 kbps	16 Mbps	2 Mbps + Wi-Fi
L2	2 Mbps	6.2 Mbps	6.2 Mbps + Wi-Fi
L3	3.1 Mbps	16 Mbps	2 Mbps + Wi-Fi
L4	300 kbps	6.2 Mbps	6.2 Mbps + Wi-Fi
L5	2 Mbps (Mi-Fi)	16 Mbps	16 Mbps + Wi-Fi
L6	512 Mbps	16 Mbps	no change
D1	4 Mbps + Wi-Fi	8 Mbps	no change
D2	2 Mbps	8 Mbps	no change
D3	2 Mbps	8 Mbps	4 Mbps + Wi-Fi
D4	256 kbps	16 Mbps (Mi-Fi)	6.2 Mbps (Mi-Fi)
D5	3 Mbps	6.2 Mbps	6.2 Mbps + Wi-Fi
D6	2 Mbps	6.2 Mbps	no change

applications were explored and understood. This played out differently in each household, of course. A child going online is at once a phenomenon of pride, anxiety and uncertainty—many parents were less tech-savvy than children and were resigned to trusting them on their devices. Older children received more independence from parents, with technology ownership and private space being signs of growing up. In some households, devices circulated within the family unit, with younger children inheriting older, out-dated or broken-screen devices.

5.8 Purposeful Wi-Fi

In spite of relative high limits (the average data cap for the new broadband plans was 15 GB), seven households explicitly rationed use by turning off Wi-Fi at nights or when members stepped out (explaining some puzzling results in [13]). Frugality norms were a key factor. Indian residences have wall-switched electrical sockets, making it easy (and habitual) to turn off devices when not in use. Azam (L3) explained how turning off the Internet helped him reflect of the purpose of Internet use and spoke of consumption as a class marker.

“We are used to switching off lights and fans when we are not using them. It’s our middle class mentality. We cannot keep it running non-stop like rich people. Whenever we want, we turn on the router and use the net. This makes us think hard about whether to do timepass or useful things on the Internet.”

(In his explicit framing of middle-class frugality and discipline in consumption, Azam might have been one of Dickey’s [6] or Säävälä’s [42] South Indian informants.) Given that it was hard to understand what 15 GB was and how much they were using (cf. [5, 43]), it is not surprising that households took blanket measures to control usage.

Switches were not the only method of controlling consumption. Some households took the alternative strategy of front-loading bandwidth-intensive usage into the first two weeks of the month and using the Internet for lightweight activities afterward. This method of maximizing utilization contrasts with the back-loading (end-of-the-month) usage pattern seen in South Africa [5] and our baseline dongle users (Sec. 4.3), and may be explained by Indian

ISPs throttling fixed subscribers who reach their cap as opposed to cutting them off.

6. AFTER THE STUDY

Three months into the study, the sponsorship for the new connections was stopped, per study protocol. We conducted follow-up interviews with the study participants one month after disconnection. We learned that most (8/12) families had switched to high-speed plans with Wi-Fi. The upgrades are significant because none of the families had ever changed or seriously considered changing their ISP plans and only two households originally had Wi-Fi.

Upgrading households obviously found value in switching to a higher speed and ability to connect multiple devices, but affordability remained a prime concern. Most switched to a mid-tier plan two levels up from their baseline, costing Rs. 100-400 (USD \$1.50-6.00) more per month. Take, for example, Gaurav (D4) and his family, who decided to get a better speed plan compared to his previous plan. According to Gaurav, 6.2 Mbps was a very good speed at a reasonable price. Since fixed line infrastructure did not exist in his neighbourhood, he was provided with a wireless mobile broadband—Gaurav decided to continue with the wireless dongle for its portability and ability to connect to his friends' devices while studying for civil services exams.

Of the four households that retained their baseline plans, three already had baselines of 2 Mbps or more. All pointed to the lower tariffs, with some citing additional factors. Prashanth (D2) enjoyed a good relationship with his local cable service agent, who *“repairs Internet problems even at 2 AM and is fine with waiting 3-4 days at the beginning of the month for payments.”* Sikander (D6) shared his motivation to continue with his original fixed line connection:

“It was very good. But I have to support my family. Maybe when I get more money I will upgrade. For now this is good.”

All the households noted that their perception of the Internet had changed to a more positive one. Saleema (L5's wife) noted that she now explored websites that she previously abandoned or did not know about, such as *“cooking blogs, Yoga and Zumba videos at home, e-learning modules for kids, tennis and cricket matches for my husband, and bhajans for my mother-in-law.”* Sohail (L1) explained how his perception of the Internet had changed:

“Before it [the Internet] was okay, useful. But now only I fully understand the potential of it. We cannot live without it. After selling cars online, my son is going to create a website for my business so we can do transactions with people in foreign countries. It has so much business value.”

7. DISCUSSION

Urban households are increasingly adopting and blending Internet technologies into their daily practices. Although not definitive, with a step up in speeds, we learned in our study that the perception of the Internet became a lot more favourable and positive, with users tracing new contours online with more time spent online, higher bandwidth activities, new forms of Internet skilling coexisting with non-instrumental users, and exploring new spaces and devices with Wi-Fi. In a longitudinal setup, some of the behaviours and attitudes tended to persist even after the connections were terminated. Below we discuss considerations for infrastructure upgrades based on our study.

7.1 Upgrading infrastructure

As we learned in our baseline, infrastructural changes are hard to make. There can be no clear benefit; there are cost deterrents; and it can feel permanent. Despite ISP availability, users did not perceive sufficient value in high-speed Internet before being able to experience it. Indeed, in the words of Star [48]: infrastructure is mundane and invisible. In the context of their long-standing constraints of slow speed or high cost, our participants had created workarounds and practices that were stable parts of their everyday lives (here the infrastructure ruptures were regularly visible, but integrated into daily routines, as Larkin points out in [25]).

To explore the full spectrum of the Internet [56] for social and economic development—say, to upload user-generated videos, participate in MOOCs, or transfer money online—a reliable, (relatively) always-on connection is key. Indeed, as we have seen, supply existed in all the neighbourhoods but demand was lacking. With longitudinal immersion of high-speed Internet, all households underwent a phase change in volume of use, types of use, utility and value perception of the Internet. 8/12 switched to a higher speed with wireless access. Consequently, the value perception, integration in daily life, and expectations from the Internet transformed, whereas skills and capabilities of individual users improved to take advantage of the full stack of the Internet.

A principal policy implication could be to foster try-before-buy models with broadband service, which may involve different types of infrastructure investment. One example would be construction of *immersive zones* with high-quality, reliable, and (relatively) long-term experiences in everyday areas like community parks, train stations, or shopping areas. Another example would be awareness campaigns around *demand aggregation* (as with, e.g., Google Fiber's “fiberhood” program), which is usually thought of as economic risk mitigation for ISPs building new wired networks [7] but can be used to engage local community attention to the possibilities of higher speeds and offer the opportunities for hyper-local demonstration venues. A third example would be to offer *reversible trials*—perhaps with a few months of sponsorship or subsidized costs, but definitely with the commitment (as in this study) that the old service can be continued if the new service is unsatisfactory.

Eighty percentage of data subscribers consume less than 100MB per month in India, most of it on 2G [57]. While we see that higher-speed broadband plans have potential to accelerate access, they are less friendly to lower income segments. Broadband may potentially be demanded of the government, and not require consumer payments, such as public goods from the government like food supplies and disaster relief. With emerging, vocal campaigns like “Save the Internet” for net neutrality gaining tremendous visibility in developing countries [2], cheaper, better quality Internet to enable citizens of nation-states to benefit from knowledge and information economies may not be far off. Even for the rising middle class, broadband has to be affordable by fitting into the affordable budget on mobile data and Internet costs. As we saw in Nagina's case, higher speed Wi-Fi can provide a reasonable alternative to 3G data plans and slow DSL.

7.2 Onboarding to new infrastructures

Learning how to use higher speeds was an extended process, and it depended on a combination of catalysts, including sufficient devices, user awareness, and willingness to explore. The home setting was conducive to free-form exploration in a relaxing, safe, and private environment, with abundant access to intermediary agents such as children and neighbours. Households faced starting

problems with exploring new speeds. Through trial and error, social recommendations and exploration of possibilities, households adapted to broadband and assessed what to do when things did not go according to plan. The phases of learning were progressive and accelerated upon faster speeds. While the volume and type of activity changed, even for previously used websites, the turning points for meaning-making online were when economic, productive, and instrumental uses were uncovered. The key experiences often hinged on rediscovering something familiar or presumed in new light, discovering unique learning opportunities with relevance for one's needs, responsiveness of Internet services, and finding multiple value dimensions.

We would like to briefly summarize the participants' perceptions of whether this intervention addressed some of their own goals that might be defined as "development" in a different, perhaps human development, sense. We do this by listing the kinds of usages that they felt were compelling enough to mention to us, whether instrumental [30, 38], ludic [3, 24, 45], or symbolic [33, 44]. Here we list some outcomes, but certainly not a complete list:

- watching videos without buffering;
- video-chatting with distant relatives;
- uploading selfies and user-generated videos in seconds;
- using Internet search for practical daily needs;
- exploring one's city through the lens of maps;
- discovering and downloading safety apps for women;
- shopping online in minutes;
- booking tickets without network timeout;
- developing one's skills online through self-learning;
- downloading movies for family-viewing in minutes.

It is hard to say whether or not the intervention failed to meet any of the participants' other development goals that were not expressed to us, or which usages were somehow "most" important. What we do know is that, after having avoided upgrades for years, the benefits were compelling enough for them to research and purchase their own upgrades. How can we make it easier to learn to select and tailor experiences for one's life-needs? Onboarding new users with various web and application skills could enhance literacies needed to explore high quality networks. Training programs could be initiated by ISPs at the time of installation with social agents or self-guided experiences upon connecting to the Internet. In a recent study, Mozilla trained new Internet users in Bangladesh to use smartphones, browse, use apps and application stores, learn about privacy, and create content [31]; users who were digitally trained were more deeply engaged with the Internet and more confident. Programs like Helping Women Get Online [14] could tailor Internet skills training by focussing on specific user groups (e.g., female seniors) and their values, lifestyles, and aspirations.

8. CONCLUSION

We introduced higher-speed service and Wi-Fi to households with narrowband Internet access. The households had remained on their original speeds, caps and wired connections since taking up the plans years ago. We highlighted how the Internet infrastructure was explored, owned, leveraged, and modified to feed into the households' motivations, values and desires. Children and youth were catalysts for their families to explore relevant use cases quickly, whereas the home environment allowed longitudinal immersion in an organic, relaxed setting. High speeds led to increased user engagement with Internet applications and websites; increased time spent online; more instrumental activities that explored rich uses for the Internet;

time and money being saved; and escalated the value perception of the Internet. One month after the study, 8 out of the 12 households converted to higher speed connections with Wi-Fi. Whether this generalizes to other populations is not something we can predict from this qualitative study, though experts in area studies might consider whether the social, cultural and economic circumstances here resemble those of the populations with which they are familiar.

We posit a relationship between higher quality Internet and ICTD. Under the right conditions, higher quality Internet can spur developmental capabilities. The study of speeds, and relevance, cost and coverage, could help identify opportunities and barriers for governments and telecom operators to introduce higher bandwidth pervasively and inclusively. The instrumental activities explored online here, such as information search, online commerce, or content streaming, mirror higher income household behavior [22]: future research can explore the impact of high quality Internet on socio-economic development among low income communities. While our study focussed on broadband, future studies could, for example, focus on LTE in peri-urban and rural communities. Higher speeds and wireless Internet, combined with user motivation, skills, and intent could engender new capabilities and experiences online. Moving from basic Internet access to rich speeds and digital literacies could benefit billions of Internet users throughout the economic spectrum.

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