Data sufficient products: speculative design explorations for sustainable digital futures

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Abstract

Information technologies promise to make products and services more efficient and sustainable, yet the ICT industry has a substantial ecological footprint that is only expected to grow. This calls for actions beyond improving product efficiency. To this end, we explore whether demand for data can be moderated by encouraging 'sufficient' usage. We combine behaviour change theories with a critical design approach and conduct a Research through Design exploration of online consumption speculating about possible directions for reducing data use. Partnering with an internet service provider, we designed and tested with end users a set of three provotypes embodying data-sufficient design directions. We reflect on the results to argue that across the entire system of stakeholders, there is insufficient awareness of the environmental impact of data technologies. Further, we conclude by highlighting that contrary to the belief that interventions aimed at reducing consumption harm user experience, our results show that moderating data intake might actually even improve it.

CCS Concepts

• **Human-centered computing** → **Interaction design theory, concepts and paradigms**; **User studies**.

Keywords

Human-centred design, design for behaviour, systems thinking, critical design, research through design, human-computer interaction

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1 Introduction

In only two decades, information technologies have become omnipresent in the lives of more than half of the global population [22]. These have great potential to improve communications and enhance the efficiency of many services. Yet, the sheer size of the total infrastructure behind them has led to a critical discussion on the environmental footprint of the network itself [3, 6, 39]. With 900,000 km of cable already running below our feet [20] and the largest data centre almost covering an entire square kilometre [67], this footprint plays a substantial role in how humans impact the planet. According to recent studies, the total carbon footprint of the ICT sector has risen to 1.8% of global emissions; the highest estimates place this figure at 3.9% [27]. This is comparable to major industries such as aviation [24] that have been subject to wide-ranging societal debate. One of the major causes of this persistent growth is that efficiency improvements are curbed by exponential increases in use – the so-called *rebound effect* [68]. For example, experts argue that despite the increasing use of more efficient computing in the cloud, the gaming industry could see its total emissions double because of gaming becoming far more accessible [41]. Similarly, the recent developments in artificial intelligence (AI) are seen to be catalysing a radical increase in data consumption, with training costs of a single natural language processing algorithm being compared to the carbon dioxide emissions produced by five cars over the cars' lifetime [63], and the energy costs of deploying AI algorithms being estimated to surpass the training after a few weeks or months of deployment [35].

Thereafter, whilst digital services do enable far greater convenience and make services more accessible, their expansive adoption could start to threaten progress towards climate goals. Further, these rising emissions not only add to the carbon footprint of ICT but also burden the availability of finite natural resources. The underlying material network of cables, devices and computing powerhouses puts stress on the availability of critical raw materials, reserves of fresh water and supply of green energy for other usages [6, 20, 55]. Adding to the list of negative consequences, the realisation of human values is hindered by the quick rise of digital products and services, such as privacy, security and well-being, along with the risk of fuelling discrimination and social inequality [7].

To tackle these concerns, a growing body of literature provides alternative – more sustainable – perspectives on the development of digital products and services and on how users may interact with them. Two emerging paradigms seek to balance efficiency and demand so that we might stay within planetary boundaries and achieve a level of sufficiency [14, 18, 43, 51, 57, 73]. On the one hand, environmental impacts could be reduced by minimising resource usage at the product level through eco-efficient design strategies. On the other hand, moderating data consumption at the use level could curb the demand by influencing interaction patterns [51]. Moving towards this sufficient level of data consumption could then positively affect value conflicts in a win-win scenario [72].

In this paper, we focus on the second paradigm and explore through a case study whether altering the interaction between user and product/service can effectively moderate data consumption. In real-world design cases, moderating use might prove to be a disadvantage for providers of digital products/services (DSPs) who will have to engage less with their customers, losing out on revenue [72]. These conflicting interests highlight the importance of designing with the complete system of stakeholders in mind – this is considered a necessary process that can reveal opportunities at multiple levels other than solely the user [10, 46]. Within this case, we investigate data sufficiency together with KPN, a major internet service provider (ISP) in the Netherlands. By keeping both their interests and those of internet users in mind we explore how their relationship could facilitate a moderation in data use. In the remainder of the paper, we first elaborate on a literature review and exploratory study of the value conflicts arising from data consumption. Next, we discuss the development and assessment of various prototypes aiming to decrease data consumption among KPN's users, leading to reflections on the implications of the sufficiency paradigm on the perception of the unsustainable data consumption problem at large and on users' experience of digital services. We conclude with recommendations for data-sufficient futures.

2 Understanding data as complex sociotechnical systems

Understanding the dynamics of data consumption calls for a systemic view and a close look at the entanglement of various stakeholders [51]. To this end, we engage with existing literature from business and economics, science and technology studies, as well as human-computer interaction (HCI) and its sustainable counterpart (SHCI) to delineate the key components of data ecologies and their relations.

2.1 Data intricacies

Across the complex network of infrastructural hardware, devices and digital services, we distinguish three main perspectives based on the work of Preist, Schien and Blevis [51] to represent the stakeholders within the data landscape: consumers, DSPs and facilitators of the network. We discuss the role of governing bodies from all of these perspectives.

2.1.1 Consumers engaging in 'mindless' data consumption. When seeking to moderate data consumption, it is important to grasp users' data-consumption behaviours and their perception of the impact of digital services on their lives. Given the immense complexity of the physical infrastructure [20] and the need for people to be educated on interacting with digital systems, it is likely that users currently lack the knowledge needed to understand the real-world impact of using online services. As Cubitt [21] argues, end users perceive digital products to have either no ecological footprint or one that is so limited as to be negligible [21]. While data-saving 'lite' versions of digital applications do exist, these serve as a means to save on data plans or increase accessibility on less-developed networks instead of reducing ecological impact [1, 42]. This lack of awareness illustrates a seemingly careless way of consuming digital services that is further accelerated by the high accessibility of the internet, with most data plans being offered on an unlimited basis, under flat-rate monthly data plans [58]. Internet connections have become as ubiquitous as tap water, an infinite supply that should always be available at a low cost. Paradoxically, while consumers desire cheap and unlimited data, they also consider that spending too much time online is 'digital waste' [52]. In these cases, excessive amounts of time online can stand in the way of having meaningful experiences offline [73]. It is difficult, however, to differentiate meaningful use from this mindless consumption of the internet, making it hard to create effective interventions to moderate it.

2.1.2 The unregulated market of digital service providers. Whilst consumers are mostly unaware of the impact of their behaviour, the current economic system encourages DSPs to further stimulate data consumption. Without any regulatory intervention, expansionist online platforms aim to build consumer bases large enough to dominate markets as oligopolies in a winner-takes-all scenario [56]. Once they have accumulated a critical mass of users, businesses employ data collected about these users to further stimulate consumption [75]. This business model, also coined surveillance capitalism by Zuboff [75], intensifies mindless consumption behaviour as it inspires dark patterns, and addictive features that compel users to engage with digital services [15]. This in turn generates money as viewing advertisements transforms the attention of users into a commodity that can be exchanged as payment [9, 17].

For the DSPs, the revenue created by this attention economy currently outweighs the costs of operating their services. Many of the real-world impacts, however, are not attributed to this stakeholder as energy costs are spread out across the network's many devices and ethical impacts affect other stakeholders such as the previously mentioned consumers and content creators and moderators who have to perform stressful labour [23, 33, 34, 38]. A lack of transparency and regulations [9] makes it hard to hold service providers accountable. The Digital Services Act, however, is meant to better protect consumers and their autonomy in a major attempt to regulate online services but has yet to take effect [31]. To sustain such a high rate of consumption puts stress on both natural and human resources. Immense amounts of visual content need to be created and moderated. Some workers and creators are pushed into overdrive and many suffer from psychological trauma from their insecure and stressful jobs in this volatile market where only a few can earn a normal living [23, 33, 34, 38]. In a similar vein, the environmental impact of online services is also overlooked; without proper accounting for the impact of digital services, it remains difficult to attribute the impact to service use. A case study on the video platform YouTube, however, shows that DSPs' design

decisions hold great potential for decreasing emissions, even when compared to conventional measures such as the usage of green electricity to power infrastructure [52]. Adopting a data-sufficient mindset could therefore prove an interesting avenue for DSPs in reaching sustainability targets.

2.1.3 Cornucopian thinking driving network development. ICT infrastructure and its growth are seen as a fundamental part of the future economy. The Netherlands, for instance, already relies on ICT for over a quarter of its national GDP [54]. Current policies look to computing optimisation and hardware improvements to reduce the ecological impact of digital products. The planned developments in efficiency optimisation alone, however, cannot mitigate the tremendous rise in demand resulting from the explosive growth of digital products and services that society is currently witnessing. Efficiency improvements are outpaced especially by the fast-growing demands of emerging AI applications [74]. To get a sense of the scale of the environmental impact of AI, Strubell and colleagues [63] estimated that solely training an algorithm may generate carbon emissions that are roughly comparable to a trans-American flight. Even worse, these technologies too come with serious social implications, especially because data labelling and training of algorithms still require hard – and underpaid – manual labour [71].

That said, there is resistance to this cornucopian mindset that subordinates human and planetary resources to technological improvements. It is the subject of debate and criticism in both academia, especially within the SHCI community [43, 51, 72], and civil society, where the expansion of networks and data centres is facing unforeseen obstructions in the form of civil unrest [47] and a shortage of data centre employees [48].

In conclusion, the data ecology that has formed around the total network can be understood to comprise a complex sociotechnical system where the consumers' mindless consumption of data is deeply intertwined with the offering of services originating from the unregulated market for digital services, and both are encouraged by overly-optimistic cornucopian thinking that also drives network development. Altogether, these three interdependent issues delineate how the data ecology is trapped in a tragedy of the commons scenario where the resource that might be depleted is not the data itself, but rather the human attention and planetary resources that data consumes (Figure 1).

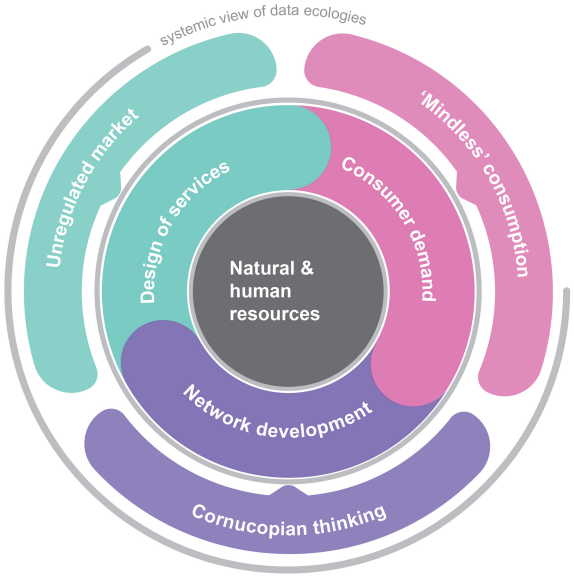


Figure 1: Factors influencing data consumption mapped onto the system as visualised by Preist, Schien and Blevis, 2016.

2.2 Design approaches for sustainable change

2.2.1 Eco-efficiency and sufficiency. Two paradigms have emerged from the literature in SHCI and design to decrease the footprint of digital services: eco-efficiency and sufficient consumption. The notion of eco-designs that aim to make more efficient use of resources is already commonplace in the design of physical products [37]. The development of these designs and regulations that encourage them have proven to be highly effective in reducing ecological impact [26], given that the efficiency gains outweigh the impact of additional hardware production [10]. Extending the approach from physical products to the digital realm therefore seems a likely next step in mitigating ICT emissions [51]. A case study on the video platform YouTube shows that removing video streams from audio content where the user is not watching could realise substantial GHG reductions [52].

Setting limits to normalised levels of consumption, however, is a less studied subject and many questions remain unanswered. In the sufficient consumption paradigm, reducing the impact of digital services is reframed as a user-focused design challenge rather than one centred solely around sustainability. Widdicks and Pargman [72] argue that the social values of end users can be leveraged in the overall quality of experience to mitigate potential losses in usability or hedonic values [72] that are typically satisfied by addictive services [40]. A study on smartphone use seems to confirm that reducing usage can have benefits for both subjective and physical well-being as opposed to normal use or total abstinence [12]. SHCI researchers identify opportunities for uncovering additional values, establishing social etiquette around data use, co-creating what 'sufficient' use might look like and exploring business potential around the aforementioned strategies [72]. Exploring this new way of interacting with online services touches upon sociological, psychological and economic principles, which calls for the interaction design field to collaborate with other disciplines [29]. Given the emphasis on the consumers as agents for change, we see behaviour change theories as a promising grounding for understanding how the sufficient consumption paradigm could be implemented. Although this body of work does not as yet address sustainable consumption of data specifically, it provides broad sets of strategies [8, 28, 70] for bringing about changes in consuming habits that align with many of the proposed types of interventions suggested by recent SHCI works [10, 73]. These strategies, for instance, are currently applied in other domains to shift towards

(sustainable) plant-based diets [25] or to reduce the consumption rate of end-user devices [44, 65].

Additionally, in the framework of Bhamra and colleagues [8], which aims to reduce the environmental and social impact of products by moderating how consumers interact with them, attitude change is thus considered the first of three essential steps in creating new consumption habits [8]. Other levels stress the importance of habit formation (e.g. through nudging or gamification) and the possibility of normalising these habits through easy-to-maintain everyday rituals. Distinctively, in the case of data consumption, the intangible nature of information technologies might prove to be a big hurdle as it makes it difficult for consumers to perceive the issue. Without appropriate awareness of their impact, consumers will not have the desire to change. To transition towards a sustainable digital future, a plethora of interventions will be needed across all of these levels over a longer period of time to incrementally change attitudes and beliefs in the sociotechnical landscape [46].

In this research, we intend to utilise consumer values to explore the balance of maintaining user experience and decreasing consumption to a level of sufficiency. By applying the emerging paradigms in a commercial context, we aim to shed more light on the implications for industry.

2.2.2 Speculating through design. A growing number of authors from the SHCI and design fields increasingly highlight the complexity and controversies of applying approaches that either promote efficiency improvements as a solution to the environmental footprint of technology or predicate the need for people to change their behaviours. Jensen and colleagues [30], in particular, engaged and problematised the perspective of behaviour-change interventions, emphasising that many of these actually face challenges in both instigating and sustaining practice change [30]. Other scholars question the dominant approaches and narratives of technological and energy futures, and in particular problematise the sociotechnical imaginaries that these bring [16, 62], their incongruencies [62] and normativity [16]. As Chopra et al. [16] argue, it is important to understand "sustainability as a consequence of longitudinal social practices" and, to account for this, research should create spaces for communities to delineate their technological visions. In this line of thinking, many works mix ethnographic, participatory and speculative design research to explore possible sustainable digital and energy futures. Jensen and colleagues [30] developed a device for a washing machine that limits the usage of the appliance to times when renewable energy is available [30]. Snow and colleagues [59] developed an app that allows users to navigate the city and check the health of the local energy network- [59]. Strengers and colleagues [62], instead, used speculative comic strips to disrupt energy industry futures [62]. Chopra and colleagues (2022) used speculative tropes – presented in the form of prompt cards, fictional scenarios, and a game – to challenge normative future scenarios together with communities. Similarly, Antognini and Lupetti [4] developed a toolkit for debating energy futures with local communities engaged in world cafes, emphasizing also the need for addressing the potential for social inequalities that normative energy future visions carry.

These research works intentionally develop provocative artefacts – provotypes [11] – that disrupt existing practices and stimulate debate with participants. While useful for research purposes, however, the disruptive effect that these artefacts generate can hardly be tolerated in real products [30]. To address this tension, Jensen and colleagues [30] suggest making the very practice that needs to change the unit of design. Beyond physical artefacts, looking at habits as units of design would enable sustaining practice change [30]. Snow and colleagues [59] also warn that speculative design may be a double-edged sword: it may enable accurate elicitation of values from participants, yet it can also introduce distance, as the futures presented to participants are fictional and cannot be engaged with in the long term [59]. Thereafter, these speculative practices can help reveal problematic assumptions and understand the situated and real implications of specific design strategies, such as nudging consumers towards sustainable behaviour changes. However, these also come with methodological challenges that cannot be disregarded, especially if the ambition is to generate not only academic knowledge but also actionable design recommendations for the industry and organisations to pick up and adopt.

3 Methodology

Building on related works, this research combines the design for behaviour change theory with speculative design approaches. We grounded our investigation on a review of literature, which we integrated with contextual inquiry, to arrive at critical design directions for our Research through Design [60] investigation. We developed provotypes [11] to explore the paradigm of data sufficiency applied to the interaction between an ISP and their users, by using them in a user study session.

As a contextual inquiry, we conducted exploratory interviews with Dutch consumers, where we investigated their current relationship with digital services and their attitude towards changing it. Findings from these interviews substantiated the insights from the literature review resulting into critical areas for design exploration. We subsequently used existing behaviour change strategies identified in literature to inform the provotyping activities, aiming for both provocation and potential for actual impact.

Following an iterative process, this activity was split into two cycles where a preliminary set of paper provotypes was developed to informally test ideas with the research team and peers, informing the development of the final provotypes. These, which also embody sets of data use practices, were used to engage participants (9) during semi-structured interviews (5) and a focus group (4) and create debate around the emerging strategies for data-sufficient design. We address the methodological risks of speculative design regarding the development of actionable recommendations [30, 59] by designing artefacts and data usage practices at the same time (as suggested by [30]), and by closely working with the client KPN. In fact, working closely with industry forces the research to continuously interact with non-academic interests and to minimise the possible distance introduced by speculative approaches, as each speculation also has to be strongly grounded on its plausibility within the current and near-future telecommunication sector.

3.1 Contextual inquiry

We conducted eleven exploratory online interviews. The participants were recruited through the customer user panel of the internet

Figure 2: A selection of hidden routers in the participants' houses.

service provider involved in the research (7) and through convenience sampling (4). The resulting group was characterised by a variety of ages ranging from 21 to 68 in order to ensure diversity in terms of digital literacy. The interviews were semi-structured and involved visual exercises and the creation of 'day in the life' overviews of internet usage guided by the primary researcher in the online environment Miro. Prior to the interviews, participants were asked to document (by means of pictures) internet-related devices in their household as a means of sensitisation to the topic.

The exploratory interviews exemplified and confirmed many of the findings that emerged from the literature review. In general, participants seemed oblivious to their data use and its ecological impact in particular. Exemplary is the fact that routers were typically hidden around the house in places where they could not be interacted with (Figure 2) and that none of the participants had any idea of what would be considered a 'normal' amount of data or screen time. Besides a lack of awareness, the use of digital services then also seemed somewhat bereft of any social norms. This didn't mean, however, that participants had never attempted to reduce. In concern of their wellbeing, some had attempted to delete addictive social media apps. They experienced how quitting led to a loss of instantly gratifying content [40] that required serious commitment. Without the right support and incentive, they found themselves re-installing said apps shortly after.

Taking these insights as primary focus for our intervention, we distilled three critical design directions:

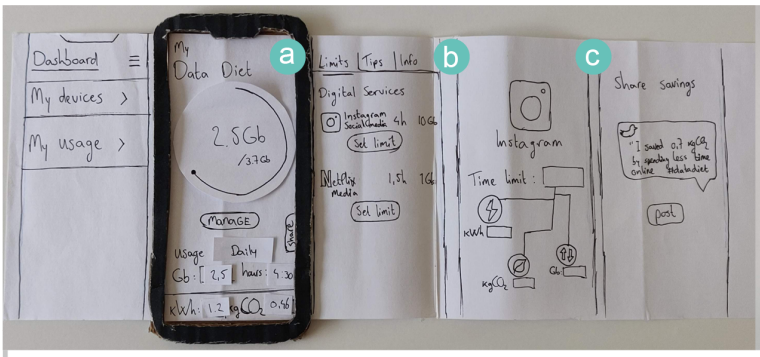
- Breaking with automated and addictive use patterns – in interactions with digital products
- Engaging with data use – as part of learning about the impact of ICT products and services
- Addressing the lack of social norms – around newly formed online behaviours

These design directions aim to tackle prominent dilemmas for data sufficient behaviour as well as interact with all stages of behavioural design [8]: intention (awareness), habit (norms, use patterns) and control (all). This allows for a comprehensive set of behaviour change strategies to be used in the provotyping.

3.2 Preliminary provotyping

For internet service providers like KPN, the main channels of interaction with their customers are digital services, such as the webpage and app, and peripheral devices, such as routers and TV set-top boxes. The provotyping activities were therefore projected upon these touchpoints. They provide a different take on current practices around these products and services to speculate on how future interactions could result in different, more sustainable, practices. Following an iterative approach, these activities first resulted in a small series of six paper provotypes (Figure 3). The paper provotypes were used to preliminarily assess whether and how specific behaviour change strategies applied within the design directions would be effective in achieving a change towards moderating data use. At this stage, informal testing and feedback sessions were conducted within the research team and with peers.

Based on these sessions we learned that all six provotypes, both the routers (R) and apps (A), could challenge the user to some extent to break with habitual behaviour, favouring purpose-driven use. Whether it was through bandwidth modulation (R1, R2) or enforcing limits to use (R3, A1, A2, A3) they might regain some *control* over their own habits. Recurring actions like preselecting usage (R2) and default sustainable options show how routine behaviour

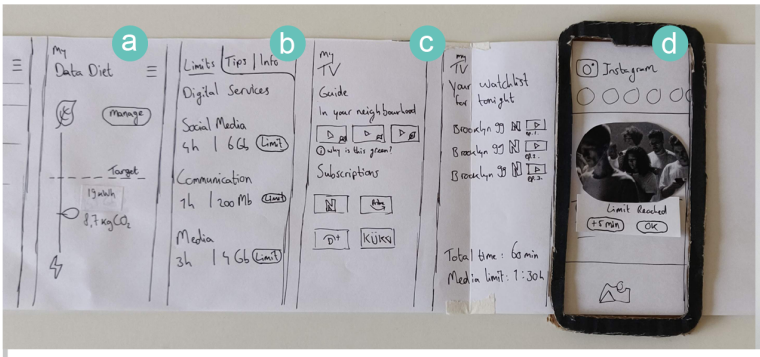


A1 Quantified feedback

Extensive insight into own use (a), goal setting (b) and sharing progress on social media (c)

R1 Switching power

Selecting bandwith modes (a) linked to benefits (b)

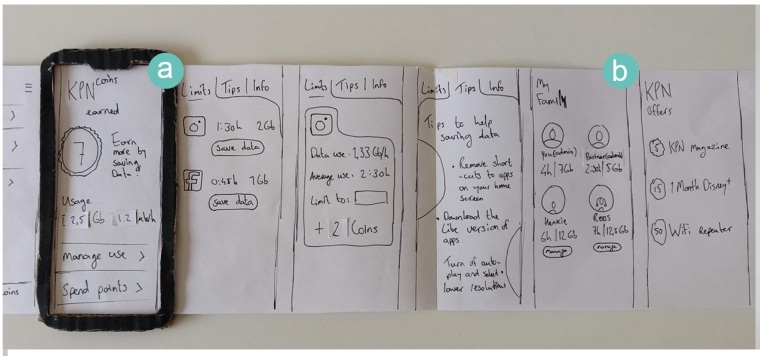


A2 Eco-centric feedback

Sustainable framing (a), use limits (b), planning a watchlist (c) and deterring messages (d)

R2 Prepaid use

Setting a data budget (a) prior to usage



A3 Gamification

Extrinsic incentives by rewarding coins for less usage (a) and competition with others (b)

R3 Usage on display

Goal setting (a) in comparison to others

Figure 3: Overview of the paper provotypes.

could make this task less demanding . *Making moderate use less taxing* hangs in a precarious balance with *creating inconveniences and friction* that discourage or restrain (R2, A1, A2) excessive usage. Although the new behaviour should not be mentally demanding, providing friction in moments where users engage in meaningless behaviour can be desirable. In this preliminary assessment of provotypes, the designs did not sufficiently distinguish between types of use. Users working from home, for example, might experience a disproportionate amount of inconvenience without being able to act on it.

To engage internet users, the provotypes mainly targeted intrinsic motivation by communicating the impact of data usage on personal values such as sustainability and security (R1, A1, A2). Although the feedback did provide incentives in theory, it was expressed in figures such as kWh and Gb that do not hold any concrete meaning for most consumers except when displayed in terms of hours of use. Making the benefits more explicit could help, but might also cross a fine line where suggestions start to feel pedantic (A2). A similar observation is made for extrinsic motivations, where gamification (A3) can be a playful way to engage users with their usage or even break with current behaviour – but can also cause frustration when anyone other than the user decides upon the end goal of the game. Deciding what behaviour should be rewarded then becomes a tricky endeavour and it might prove difficult to find rewards that do not encourage other types of consumption that are equally harmful to the environment.

At the same time, disclosing usage to others (R3, A1, A3) was estimated to bring an element of challenge and competition that did motivate change. That said, it is important to consider the behaviour of the person one is compared to – if this person's behaviour differs too much from that of the user, it could become irrelevant. The new behaviour should correspond with the attitudes and beliefs of the user and their peers to avoid negative backlash from expressing moral objections to their current data-intensive behaviour (i.e., becoming a 'do-gooder' [69]). It is therefore of vital importance with whom the feedback is shared.

3.3 Final provotypes

Based on the insights gained from the preliminary assessments, the design of the final provotypes focused on exploring how to encourage and educate costumers to have more responsible behaviors, and settled on providing personal and tailored information in social contexts. The final provotypes consist of three key artefacts of KPN's product-service system: a web page, an app and a router. These three elements together respond to the need for providing customers with more information prior to using the other artefacts, as well as accompanying the customers over their entire data consumption journey. The design strategies are embodied in the provotypes.

3.3.1 Website. We used Figma to prototype an interactive webpage where users can be informed about the social and environmental impact of data consumption. Information is provided within three impact categories – environment, safety and well-being – that correspond to a variety of personal values (Figure 4). Linked to these categories, the webpage also introduces a new plan that includes the app and router. The standard bandwidth of this plan is lowered but

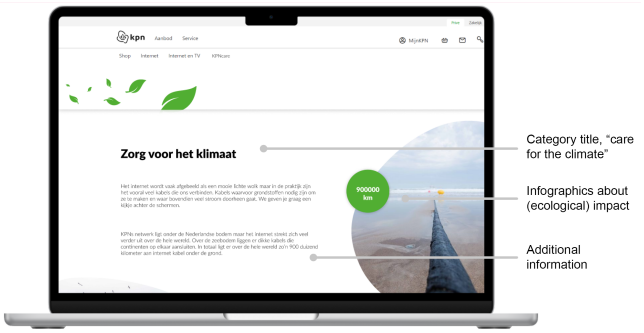


Figure 4: Website

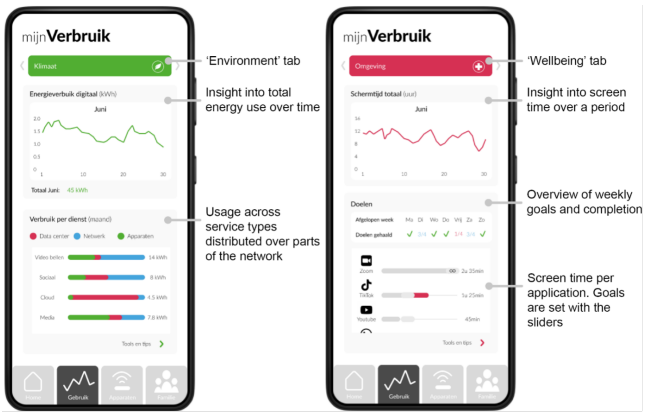


Figure 5: App

can be temporarily increased with 'boosts' for a duration predefined by the user. By providing this level of flexibility, we aim to achieve a personal experience where consumers consciously decide why and when they want to reduce their usage without being pedantic. The default, however, is to consume more slowly, lowering the amount of effort required to decide to engage in sufficient use.

3.3.2 App. The app is designed to make users aware of their personal behaviour and to provide them with insights to enable changes in behaviour by presenting them with information about their usage along the impact categories. The environment tab (Figure 5) offers insight into kWh used both in total and per type of digital service (i.e., media) to instil some level of energy literacy [66] in users. We use estimates for service types rather than specific apps as this detailed kind of information is not yet available. Distribution of the energy across different parts of the network (end-user device, network or data centre) is also displayed to provide greater guidance on possible behavioural adjustments, such as swapping end-user devices for more efficient alternatives (i.e., laptop instead of TV for watching a movie). A well-being tab keeps track of time spent online and allows users to make their intentions explicit through goal setting. In the third tab, safety, users gain insights into the physical locations (e.g. data centres) they have been connected to through their internet traffic. Furthermore, another key feature of

the app is that it provides access to a bandwidth boost. When bandwidth limits are reached, the user is notified and offered the option of activating the boost. Switching from the lower speed to boosts should provide a low level of inconvenience that establishes a balance between ease of use and purposeful consumption. Together with the webpage, these features are intended to make consumers aware of the benefits of sufficient data use and set steps towards achieving it.

3.3.3 Router. In addition to the digital prototypes we also test a physical interface. Through the design of a more prominent router, we explore how social cues might be used to steer behaviours and make data consumption present in daily rituals. The router allows users to check their devices in and out by inserting/removing a coloured key (one colour per user). Together with the boost feature, physically (dis)connecting from the network provides users with more control over use periods and enables the router to save energy when there is no demand for data. Styled as a decorative object, the interface also features a display that shows the usage of individuals in the household as coloured spots matching the keys. Resulting comparisons between household members could spark discussions or critique within the safe space of family and peers. As the appearance of the display also becomes gradually more chaotic and flashy when usage is high, it provides a visual incentive to reduce.

4 Testing the provotypes with internet users

We evaluated the three final provotypes with Dutch internet users in semi-structured interviews where the participants could freely explore all functionalities. In these interactive sessions, we observed how participants responded to the provotypes and actively reflected with them on their experiences and thoughts. To this end, we did not deem it necessary to make use of live data from participants and provided fixed visualisations of use patterns.

4.1 Procedure

We conducted the sessions in two different formats. First, five participants interacted with the provotypes individually in one-on-one interviews with the main researcher. Following the sequence of the customer journey, participants first interacted with the web page after which they evaluated the app and router respectively. Between each provotype the participants reflected on the desirability of the proposed concepts and the likelihood that they could inspire a change in their online behaviour. In an open discussion, they expressed how their lifestyles would be affected, either positively or negatively. Besides evaluating the effects on an individual level, we assessed the features intended to facilitate a household-level response in a separate session. To simulate interactions between household members, we hosted a focus group with four participants who together represented the household. During the first half of this session, we hosted a discussion on the topic of association games and inquiries into personal internet use. Once a common understanding of the context of the research had been achieved, participants interacted with the provotypes in the same order as the individual sessions. They assessed the two digital concepts in teams of two, in between which there were moments for discussion and reflection. They evaluated the router in a living room setting located in the testing facility of KPN. While the participants engaged in the common activity of watching a television series together, the router would respond to the data usage of each of the participants. To allow for comparisons to be drawn and discussion to start around the displayed usage we mimicked a family setting with different types of users. Each of the participants was assigned a role as a family member with instructions for using additional services while watching the series (i.e., social media on a smartphone).

Table 1: Study participants

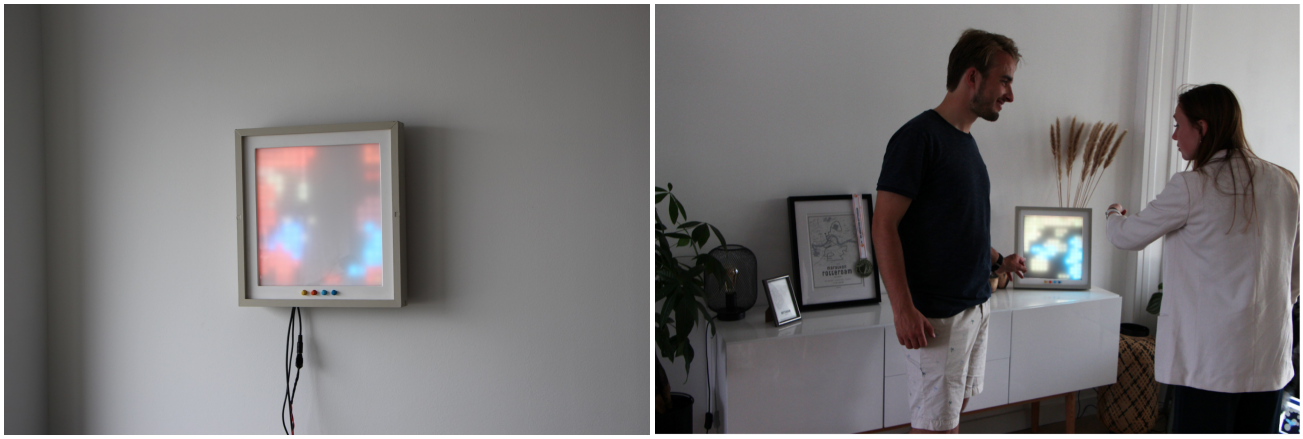
Participant Acronym	Activity	Age
P1	Interview	34
P2	Interview	39
P3	Interview	30
P4	Interview	65
P5	Interview	35
P6	Focus Group	50
P7	Focus Group	21
P8	Focus Group	77
P9	Focus Group	62

4.2 Participants

We recruited participants for the study through an independent agency. To ensure that they would have easy access to the testing facility, the selected participants all resided within the Amsterdam area. Moreover, their ages varied to ensure a good representation of different levels of digital literacy and different kinds of household members (Table 1). Participants were selected based on their responses to a questionnaire introducing the topic and the discovered value conflicts around well-being, sustainability and online safety. Candidates who had affinity with either of these topics were preferred over those who did not, as the goal of the study is to assess the appropriateness of the used strategies for a specific target audience rather than sizing the market potential of the developed concept. We only use pseudonyms for the participants in this document along with strictly relevant demographics (age) to ensure anonymity.

4.3 Data collection and analysis

Observations were made by the first author during the sessions, notes were taken during interviews and group discussions and video footage was captured at the testing facilities to allow for a more thorough analysis. The textual materials, mostly deriving from the annotations by the first author, were analysed conducting *affinity diagramming* [36] on the digital whiteboard tool Miro. We stored these notes and videos locally for the duration of the analysis, after which they were deleted. All data collected over the entire duration of the project has been stored in line with the data management plan as approved by the human research ethics committee of the *Delft University of Technology*.



(a) (b)

Figure 6: Router provotype: a) the provotype set up on a wall, b) the provotype positioned on a livingroom furniture and being discussed by two roommates

5 Results

Here we report the results of both interviews and the focus group analysed through affinity diagramming [36], structured around the critical design directions identified in the preliminary research.

5.1 Breaking with automated and addictive use patterns

With the boosts and goal setting, participants saw how they could enforce their intention to moderate their consumption in daily situations without actually being limited. Being more aware of their own habits was considered to be inherently valuable – a value that together with the social gains could outweigh the loss in ease of use. For instance, a participant mentioned: *"I might be a bit scared that it would cost me more time, but I think you will have more gains from the social benefits"* (P 1). That said, the flexibility of these features remains important. Although the boost seems adaptable to many scenarios, this slight inconvenience was also envisioned to affect visitors, which proved a primary concern. In a participant's words: *"I think I could get used to the boost, but I don't want it to impact guests"* (P 5).

Part of the reason why the participants did not consider the estimated losses in usability to be detrimental is that the actual inconvenience involved was limited. For instance, a participant mentioned: *"If it's in the phone interface then it's not a barrier, only two clicks right?"* (P 1). With the boost feature directly integrated in the OS, it would only present people with a slight 'speed bump' after which they could spend their time more meaningfully. In this way, if friction were provided in a playful way, it could become something desirable.

5.2 Engaging with data use

Presenting the participants with insights about the impact of data usage on both the webpage and the app confronted them and even inspired them to start changing things in their own homes (P 4). Even people who considered themselves to be well-educated on topics such as sustainability still considered the insights to be eye-opening (P 5). Their direct link to environmental, safety and well-being impacts made the information relevant to all of them, in one case relating to personal experiences with loneliness through online media (P 4). Few of the participants, however, cared about all three of the aspects. This underlines the importance of addressing a variety of motives and making the impact tangible. Expressing usage in terms of other forms of consumption, such as lighting, helped in creating a common language around energy. One participant also expressed unease at the idea of actively reducing data consumption, categorising it as a bit too much (P 2). They preferred to wait until it had become more commonplace and only then adopt such measures. Adding to that, personalisation was valued very highly by the participants, and they believed that it would have benefits for a wide audience ranging from 'green' consumers to ones who are concerned about safety online. One participant, for instance, stated: *"For me this (the safety page) is not very interesting, but I can see there is an audience for it"* (P 3).

However, to a majority of participants, personalisation also meant a tailored payment plan. Besides intrinsic factors, they considered extrinsic motivation to be very important for enabling them to part with their old habits. As two participants explained, in principle they would like to adopt these alternatives that encourage sustainable behaviours, but realistically this would work only if monetary incentives would also be in place (P 1, 3). If KPN were to provide these, participants recognised this new offering as a convincing value proposition. Whereas internet service providers currently compete with ever-more generous offers, these consumers no longer saw a need for such deals and longed for a more tailored plan. As some participants explained, right now KPN does not have anything that competitors do not have, and the data plan suggested through the provotypes would be different (P 3, 4, 5).

Further highlighting the use of data in the household, the material interface of the router brings insights into the physical space where it can no longer be hidden behind a screen in the users'

pocket. Although some would go so far as to hide away the router and interface completely (P 4), others saw this as an unobtrusive way to make the information more prominent (P 1, 5). As one participant explained, *"It was also visual in the app but there I have to click on it, now I would be confronted with it on a daily basis"* (P 1). All participants agreed, however, that the information would not be relevant most of the time and should be provided at given moments of the day or week when they would reflect on it. A great opportunity lies in doing this together with the family and multiple participants saw responsible data consumption as a central issue in the upbringing of their children (P 1, 6, 9).

5.3 Addressing the lack of social norms

By introducing other household members to the feedback on consumers' usage (an interaction afforded by the router), the act of moderating and setting boundaries gained a social aspect that the participants considered both fun and motivating. One of them mentioned that *"It's fun to visualise it (data consumption) like this, and then set targets together"* (P 1). Participants could see themselves playfully provoking their partners (P 3), educating their children and setting targets together as a household (P 1). This could give people the support they need to follow through on their intentions, but also demands a strong connection between the users. As participants mentioned, this approach could work in a family setting, but then everybody would need to be on board, and it is uncertain if this would work for many families (P 6, 9). Sharing usage information with others also involves issues of privacy. Disclosing such information in a more public setting requires users to agree on a 'social contract' where they acknowledge that they are taking part in the effort to cut down on their time online. Convincing children to join in might prove to pose a big challenge for parents.

6 Discussion

Based on the results of our study, here we reflect on the actual suitability of the critical design directions we explored for enabling data-sufficient behaviours. We reflect on both the likeliness of consumers to change their behaviours, as well as the potential for internet service providers to facilitate this.

Despite the fact that reduced consumption of data is generally expected to negatively impact the experience of the consumer, the overall response to the provotypes was positive. The participants we spoke to were interested in learning more about their digital footprint, showed interest in data-sufficient offerings and even indicated that obstructions to usage could serve a useful purpose. Similar to findings from previous studies [19], the introduction of small 'speed bumps', or micro boundaries, that counter the dark patterns embedded in many online services, emerges as a promising strategy that could be further investigated. These speed bumps, together with opt-in structures such as the data plan evaluated in this study, restore some of the autonomy of users of online services to act in line with their own preferences. The results show how these preferences differ quite strongly between consumers. Data-sufficient designs should respect these differences by addressing a variety of consumer values and allowing consumers to find a balance between automated features and conscious action.

Along with the other intrinsic values addressed by the provotypes, this enhanced autonomy might even be a promising avenue for ISPs to differentiate from competitors. Going beyond seamless experiences could appeal to a variety of users and is also recognised in business theory as the next step in customer-centricity [64]. Besides these intrinsic values, however, the participants in this study also expected monetary gains [64]. It's uncertain whether there's enough incentive for an ISP to actually provide such an offering. Despite earlier predictions [58], affordable flat-rate plans are still the norm and for the service provider collaborating on this project, it is unclear whether flexible plans are a viable option at this price. Along with that, the implementation of new services like the ones tested in this study would require substantial efforts whilst there isn't sufficient evidence yet that it would lead to an increase in customers or revenue. As Widdicks et al. [72] suggest, it is more likely that smaller businesses will trial data-sufficient designs first, exploring these new propositions. Additionally, here lies an opportunity for HCI reserachers and practioners to explore the viability of data sufficient value propositions.

Besides service-level changes, we observed that the engagement with data technologies should be increased to encourage sufficient use. The participants' disbelief about the impact of their habits showed how awareness about the topic can in itself contribute to a shift in behaviour, as some even listed changes they could make to reduce their internet usage. Translating these possibilities into concrete steps and actions, then, would benefit from making the digital ecosystem more tangible and graspable. If information about negative impacts remains abstract, consumers might feel frustrated with their situation and become insensitive to them in the long run [2]. Furthermore, the insights provided need to be made concrete in a way that makes sense, preferably not through abstract metrics such as Gb or kWh. This is consistent with previous SHCI research on energy futures, such as the work by Pierce and Paulos [49] in which the authors suggest ways of materialising energy and argue that as we "treat energy as immaterial, we must also recognize that we can design our world to be otherwise" [49]. Our explorations show how a tangible representation of abstract metrics can be more effective at engaging users over digital ones, to the point where it even becomes intrusive. Future work can explore what amount of provocation can still be considered functional, further applying critical design works in real-world contexts. The need for concrete actionable insights reinforces the need for more transparency across the ICT sector. To facilitate this transparency, standardised accounting of the impacts of digital service use (i.e. CO2 footprint of streaming video) is necessary, as it proved difficult to obtain these numbers during this study and they are subject to discussion [5]. Along with that, transparency about devices such as peripherals could lead to additional energy savings [53].

To create more awareness and further incentivise consumers to change we also explored the opportunity to address groups and communities instead of individuals. Social norms play a big role in consumers' intention to change, and this is also the case with online behaviour. Statements made by the participants reveal the stigmas around responsible online behaviour and indicate that unsupportive environments decrease the likelihood of changes therein. In addition to educating, interventions aimed at creating awareness should acknowledge these sentiments in society and try

to normalise sufficient consumption as opposed to relying on the unlimited data narrative that is central in current marketing outings [45]. To this end, we also sought to facilitate a dialogue between household members a technique put forward by previous studies on reducing electricity consumption [32, 50]. In the context of internet consumption, we conclude that this is best done with relatives similar to the user in question. Not only will it result in more effective comparisons [61], it also safeguards the private nature of online behaviours. We see a promising avenue for educating families where data sufficiency could become a central part of the upbringing of children. Further SHCI work could explore how parents could more easily engage their children to willingly take part in this dialogue.

Within this study, we evaluated speculative designs within the case of an ISP interacting with their customers. Although they attempt to, the provotypes that we created are unable to fully immerse the participants in the proposed interactions. To explore in more detail whether data-sufficient designs are successful in mediating a balance between automation and user control, real-world demonstrations are needed. Along with that, the involved parties in this case study were more likely to engage with data-sufficient designs than others. The participants had an increased interest in either sustainability, digital wellbeing or online privacy compared to the average internet user. Large-scale market analyses could further investigate the societal interest in data-sufficient offerings and communication. KPN also values sustainability more highly than the average ISP. They already use renewable energy to power the network and actively reduce embodied emissions of their peripherals. Along with that, KPN offers flat rates and does not sell individual consumer data to third parties, meaning that they depend less on the amount of consumption to create revenue. We expect more resistance towards data-sufficient designs from other types of consumers as well as other ISPs and DSPs. For the latter, their high reliance on attention economy business models will make it particularly difficult to incentivise them to change the services that they offer. As this study limits itself to the part of the ecosystem where the ISP interacts with the consumer, the pivotal role of DSPs employing addictive designs is still to be addressed more thoroughly. Although an effort is made to work more closely with industry partners in this study, our findings remain largely consumer-centric. To push stakeholders to further reduce their carbon footprint where they currently do not have enough incentive to do so, we shift the attention towards policies. As Bremer et al. [13] conclude in their meta-analysis, policymakers should employ insights from SHCI works to develop a solid body of rules and regulations that will enable sustainability gains. From this work, we see the potential for sustainable policies that could enforce practices of transparency and eco-design guidelines for online services.

7 Conclusion

By exploring new paradigms for the design and use of digital products and services we reflect upon the barriers and possibilities for the moderation of data consumption. Such a change towards a level of sufficient use could help further mitigate the ecological impacts of the ICT industry, which it continues to face due to the tension between exponential increases in demand for data and hardware efficiency improvements.

Approaching the challenge from the perspective of consumers and their interactions with digital products and services revealed strong dependencies between the stakeholders in the ecology of data practices and opportunities for consumers to start moving towards a different – more sustainable – way of consuming data. Even as DSPs currently develop their services to be seamless in use and cater mostly to hedonic values in consumers, we see a growing frustration in these users with the addictive and abundant nature of this type of offering. Putting social values such as sustainability, privacy or well-being central could lead to the development of customer-centric experiences, where setting limits and creating friction at moments when consumers want to reduce their usage can become desirable features. This calls for better integration of consumer values and use scenarios into the design process of digital services. Vital to these new value propositions is the creation of a common understanding of the social impact of digital products and services. Currently, consumers are inadequately aware of this topic, partly due to the lack of tangibility of the digital world and the resulting absence of public debate – this poses a great barrier to the realisation of changes in behaviour. To break with this pattern, we see a need for greater transparency in ICT infrastructure together with the creation of a common language to communicate the sector's ecological impact and a shift from current unlimited data narratives in marketing outings towards engaging consumers to use these services sufficiently. As many others have already stated, further research could investigate the standardised reporting of the ecological impact of ICT and we also see potential for investigating how a shift in the societal attitude could be established.

As the stakeholders are currently largely unaware of this issue and mostly act in their self-interest, achieving this change also depends on guidance from governing bodies through policies and incentives. Where policies aimed at slowing down digitalisation have so far been unpopular, a growing consensus is starting to emerge that over the past years, we have come ever closer to the dystopian future scenario envisioned in the Pixar movie WALL-E back in 2008. However, even as some are working on escaping into the cosmos, the rest of us ought to think about shaping a digital future that respects the planet we are living on.

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