Social Media Tools for the Bottom of the Pyramid

A. Seth, Z. Koradia, I. Ahuja, A. Mahla, D. Martin, A. Premi, Balachandran C
Department of Computer Science
IIT Delhi, India

***Abstract*—Social media tools for blogs, photo and video sharing, and online social networking websites have revolutionized accountability in governance, awareness about current affairs, and even helped in the preservation of cultural artifacts through digital media. How can similar tools be made available in developing regions, where literacy and network connectivity remain significant challenges? We will describe a variety of innovative experiments in this regard, led by non-profit organizations working on community radio, community video, phone-based messaging systems, and even engaging with communities through in-person interactions. Many of these experiments can make use of technology to scale their operations. We will describe a few such technologies that our group is building. The paper and talk will help audience understand the context for building technology in these regions, which can interestingly be quite different from the assumptions researchers often make when building systems for use in the developed world.**

I. Introduction

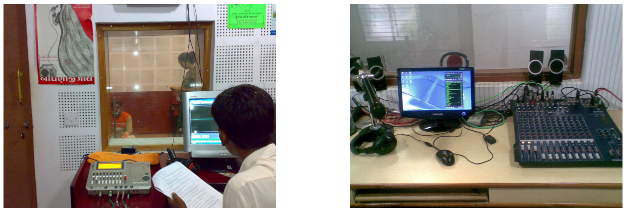
People like to express themselves. We have seen how social media tools like YouTube, Flickr, and blogging have revolutionized creativity, knowledge sharing, and even political discourse in the world. Social media is however practised very differently in rural and low-income areas of developing countries such as India. Non-profit organizations are known to train staff and volunteers in *video* recording, editing, and reporting and interviewing skills [1]. They put together films on local themes highlighting issues like corruption and domestic violence, or document the culture by recording dramas and folk songs. The films are then screened in public gatherings in nearby villages, and also sold on CDs and DVDs, or relayed over local cable TV networks. The proliferation of *mobile phones* with reasonably good cameras have also helped many villagers turn into citizen journalists and report happenings from extremely remote regions. *Community radio* is another popular medium in which radio station staff create relevant programs by engaging with communities [2]. Local production of content automatically makes it highly contextual, and restricting the range of broadcast to 10-15km makes it possible to supplement the broadcast with in-person interactions between communities and the people running the radio stations. In places where FM broadcast licenses are not available, a process termed as *narrow-casting* is used – public gatherings are organized in which programs are played over loud speakers and TV screens, and supplemented with interactive question-answer sessions [3]. If radio and video are expensive media, even *wall-newspapers* are distributed in communities, and serve to highlight important updates in the area [4].

This list of methods is in no way exhaustive, but it serves to bring out certain characteristics of practicing social media in these regions[1]:

- **Role of intermediaries**: All these methods involve skilled intermediaries, such as NGO staff who are trained in video production, or those trained in radio programming, or people with good writing skills in the local language [5]. Often these intermediaries are people from the same community, only with better education or articulation abilities, but serve a crucial role of coordinating the information production and dissemination process.
- **Text-free interfaces**: Video, radio, and narrow-casting are essentially text-free interfaces [6]. Wall-newspapers are of course printed text, but often much knowledge sharing happens in a *coffee-shop* manner when people assemble in public spaces such as tea-stalls and somebody reads out the latest reports in the newspaper.
- **Low access cost**: The cost of access for the community is very low. Community radio just requires a cheap $1 radio receiver, which now also comes integrated in most cellphones. With regards to video content, in general if a household can afford a television set then they can also afford cable TV access since subscription charges are as low as $3 a month for over 50 channels. And public screenings in the village center are essentially free of cost. Note that although the access cost to the end-user is almost zero, running a community radio or video station, or a local newspaper, is not free of cost. These are generally operated by non-profit organizations using philanthropic grants.
- **Community interaction**: Although content production for radio, video, and newspapers is done by the staff and volunteers, the process for content sourcing itself involves a lot of community interaction. The staff make field visits where they meet and record interviews with the people, or they create interest and encourage people to come to the radio or video station to convey their thoughts. Often people also make phone calls to give feedback. Community interaction is arguably the most important characteristic of these media that makes them social!

These characteristics are different from how social media is typically practiced in the developed world where intermediaries are rare, in-person and online interactions can often be disjoint spheres, the user interfaces are textual, and a one-size-fits-all Internet based system such as Facebook or YouTube caters to a large user base. We can possibly even claim that

[1]Our study is confined to the India context.



(a) Studio & control room (b) Mixer connections

Fig. 1. Community radio station setups

it is harder to practice social media among rural and low-income communities because of the wide heterogeneity in access methods, and other factors such as price consciousness, poor literacy, and high levels of personal involvement required on part of the intermediaries.

Although these set of characteristics may or may not be general principles for social media solutions in rural and low-income environments, they do raise several questions. Since a lot of the systems involve intermediaries, can technology be used to improve the efficiency of these intermediaries? Can it make community interaction smoother? Can alternate social media systems be put in place that reduce the role of intermediaries but continue to preserve easy accessibility and community interaction? Does cross-linking across communities lead to interesting dynamics? Our group has approached such questions with an open mind, and in this paper we describe a number of related projects on which we are working. We first describe our work on making it easier to run community radio stations in rural areas. This is followed by our efforts on using mobile phones for community interaction. A network architecture is then outlined to help different radio and video stations share content and learn from each other. Finally, we outline some thoughts on building non-intermediated systems that can be directly used by rural communities.

II. Community radio

Community radio stations are short range FM stations that cater to the information needs of communities living in the surrounding areas. These stations are typically setup and operated by non profit organizations or the local communities themselves. A small team of staff and volunteers is trained on content production and script writing, and makes trips into the neighboring villages to actively solicit feedback and participation from the community. Fig. 1 shows a typical CR station setup – a recording studio that is sound proofed using locally available material, and an adjoining control room with computers for audio editing and playout. The actual broadcast happens by connecting the audio playing out from a computer to an FM transmitter.

Our field visits to CR stations in India revealed several inefficient workflows that could be improved through the right technological interventions, and make it easier for the staff and volunteers to run CR stations.

- The stations in India were using media players such as Winamp and iTunes to schedule programs; this did not allow the station operator to manage time slots of when to speak live on air, or to easily ensure that, for example, a morning prayer which needs to be telecast at 8am is actually telecast exactly at that time.
- Content was stored in Windows folders, often distributed across multiple machines, making search and retrieval hard and heavily reliant on personal memory. If somebody were to leave a station, the remaining staff found it hard to locate content that that person was managing.
- The amount of moving parts in the station were plenty. Different sets of headphones were needed to listen to archived programs, or to monitor what was going live on air, or to receive phone calls. Mixer settings often also had to be changed during live transmission. This not only made the transmission error prone, but the complexity also made the configuration hard to debug in case an audio cable was accidently pulled out or a wrong knob on the mixer was turned.
- Telephony was cumbersome because significant manual operations had to be performed on the mixer to archive the call or put it on air. Many stations were in fact recording phone calls by just holding the phone next to a handheld recorder. Conferencing was also hard because different phone instruments with audio-taps were required, and muting/unmuting callers in real time was chaotic to manage. Conferencing could otherwise have been quite helpful if, for example, agricultural experts would remain dialed-in while listeners made calls to ask questions.

Our goal here was to create a system that would make it easier for the CR staff and volunteers to run the station – efficiency improvements would leave them with more time to focus on important issues such as the actual quality and format of the radio content. And additional features such as SMS and conferencing could lead to new ideas for programs and audience interaction. With these thoughts in mind, we designed the Gramin Radio Inter Networking System (GRINS) which is currently in use in eight community radio stations in India, and slated for more deployments in the near future. We are currently monitoring the usage of GRINS to see how much direct impact it can actually bring to the station, and indirect impact to the community.

A. *GRINS overview*

GRINS provides a single console to perform a large variety of operations. This includes the ability to schedule playout of programs on air, listen to archived programs while another program is playing, speak live on air and record the live speech, and monitor the broadcast audio on headphones. Telephony integration is seamless: through the same GRINS console the radio jockey can receive and make phone calls, record phone conversations, and handle conferencing. A contact manager is also integrated to maintain a community database of listeners and callers. Content management is made efficient by annotating programs with metadata, and exposing by a faceted metadata search to find programs [7]. Extensive diagnostic checks are also in-built to detect problems or faulty configurations.

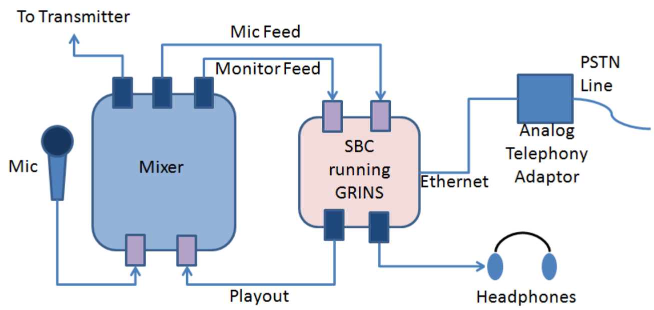


Fig. 2. A radio station setup using GRINS: The single board computer (SBC) running GRINS is connected to the mixer, which is in turn connected to the transmitter. Telephony adapter allows connecting PSTN line to the SBC

We are also building SMS processing and IVR capability in GRINS, to enable applications like automated feedback collation and polling to help the radio station know its audience better.

Figure 2 shows the schematic of how a *GRINS SBC* typically plugs into a radio station in a single machine configuration. The GRINS playout soundcard and an external microphone connect to the inputs of an audio mixer for broadcast, and the combined mixer output goes to the FM transmitter. A duplicate of the mic feed is also brought into GRINS for archival. Similarly, a duplicate of the broadcast feed ($\sim$ monitor feed) is brought in separately through a different sound card, and directed to the headphones. The same headphones are also used to listen to archived audio, so that the operator does not have to physically change over to a different set of headphones to listen to different streams.

An Analog Telephony Adapter (ATA) is used to connect a PSTN line to the GRINS SBC. The operator can pick up the call through the GRINS console itself, and talk to the caller using the same headphone and mic. The call is automatically archived, and can also be put live on air by redirecting both the incoming and outgoing telephony audio streams to the playout soundcard in GRINS. Conferencing is supported if the station has multiple phone lines. Finally, all recorded content can be tagged and made available through a single library interface.

The GRINS user interface hides all this complexity. The simple interface and workflows are now being used on a regular basis in our deployments by even highschool graduated radio station staff who have never had significant prior exposure to computers.

B. GRINS usage

Although GRINS has been in consistent use in the field since only the last few months, we have come across a few anecdotes where it has been helpful. At a deployment with a migrant worker community, the telephony feature was used to call into the station and do live broadcasts of traffic situations in the city. Broadcasts were also made of telephonic interviews with police officials; these interviews are otherwise hard to come by because government officials rarely take out time to come to the radio station for interviews. At a rural deployment, a similar technique was used to broadcast community meetings in which decisions were taken about construction projects that should be floated in the village. This helped increase transparency of the decision making process. The conferencing feature was also useful to run live question and answer sessions – the station would dial-out to experts and invite questions from the audience. At another remote rural deployment, the Internet streaming feature proved useful for the parent non-profit organization to monitor the content that was being broadcast on air. Similarly, categorizing and searching content by facets was helpful to draw out reports and statistics about women related and health related programs that were telecast earlier. At another station which wanted to broadcast 24 hours, the scheduling features of GRINS were helpful to ensure timely broadcast of certain featured programs. Finally, diagnostics proved useful to detect a certain bug that caused disk usage to rapidly increase, but this was corrected through a patch we remotely installed.

We are currently studying logs from different deployments to observe differences in usage behavior, and get hints on which features work and which do not.

C. Technical challenges

Behind the simple interface is a snarl of software and hardware. Significant technical challenges needed to be solved to get GRINS running in a robust manner [8].

We wanted to keep costs as low as possible to reduce the entry barrier for radio stations to use GRINS and simplify their workflows. Commodity hardware such as Intel Atom 1.6 GHz boards were at the right price point, but being able to handle three soundcards and LAN communication proved to be a challenge for such underpowered processors. It often led to interrupt misses that would skip audio samples and create dissonance in the broadcast audio. Latency was another issue if audio coming in through the phone was to be routed on air, or to the soundcard connected to the headphones. We created novel experimental setups to profile resource consumption at different layers – driver, codec, resampling, application – and analyzed the behavior to uncover bottlenecks in the system. This helped us discover and solve several bugs in open-source software that we were using, and to alter parameters such as buffer sizes and interrupt interarrival times so that audio quality was not compromised.

Another constraint imposed during deployment was that different CR stations required fairly different setups. For example, newly established CR stations with limited funds preferred to perform all their tasks on a single low-end machine, but older or bigger stations wanted to handle many phone lines in parallel and manage a large content database requiring a more extensive setup. Similarly, we saw that stations that had been running since a while and had become comfortable with their ways of recording or editing audio programs, did not want to change their processes drastically. This normally had to do


Fig. 3. Neeru, a community video reporter, gearing for a shoot. And a screening in progress.

with continuing to use Windows and to not shift to Ubuntu on the playout machine as required by GRINS. We solved these issues by designing GRINS in a service oriented manner. Playout, archiving, telephony, library, etc, are all different services that can be run on one machine or off different machines, and use a simple IPC mechanism to communicate with each other. Except the telephony service that runs only on Ubuntu, the rest of the services are portable. This service oriented architecture thus brought in both fault isolation and also enabled us to run some services on Windows and others on the GRINS SBC, depending upon specific requests of different radio stations.

We mentioned earlier the problem of diagnosing faults or careless misconfigurations in radio station setups. Since GRINS is closely integrated into the setups, this gave us an opportunity to build tools that can effectively test almost all parts of the radio station and accurately identify the point of failure. We did this by developing a formal way to represent a radio station setup using Prolog, and then infer faults based on the results of different automated tests [9]. We also found that not all setups were entirely *debugable*, but left over some amount of ambiguity in locating the fault. We used this to develop a metric for *debugability*, which could be used to compare different setups with each other. This can be handy because the flexibility of GRINS actually allows us to deploy it in different configurations, and such metrics could in fact help evaluate trade offs between cost and debugability to choose configurations.

Our involvement with community radio so far has convinced us that there is definitely room for technical innovations to simplify operations, but these innovations cannot be done blindly. It is essential to closely observe workflows and gather insights into inefficiencies with current ways of working, and only then build suitable technology to address these issues.

III. Community engagement

Video Volunteers pioneered a revolutionary model for community video. A few youth from the community are identified and trained in the art of documentary film making, right from identifying an issue to research on the issue, understand who should be interviewed, develop a structure, travel and take recordings, and finally put together a coherent story that ties the different parts together. A distribution team then takes this film and organizes public screenings in the neighboring villages. These screenings are typically held outdoors in the village square or some other central but open space, and are attended by huge crowds often up to 300 people strong. The screenings themselves happen simply through a DVD player, loudspeaker, and a data projector that the video unit staff carry around on their motorbikes. The more interesting part is that the screenings are followed by a call-to-action around the issues addressed in the film, such as against corruption, or better sanitation facilities, or the status of women in the community, etc.

The level of community engagement that such work requires is phenomenal. Currently, Video Volunteers tries to manage this by having people call their video team and ask questions, but this is often sub-optimal because it pulls away the team from their core work, and requires coordination to pass on the contact details of the right expert to deal with the question. Similar challenges also arise with community radio stations and wall-newspaper organizations, or rather with any group that works with a large community. People want to call in to ask questions, give feedback, lodge complaints, report incidents, and hear the experiences of other people. The concerned organization in turn wants to use the feedback, redirect questions to the right authority, and give updates. But all this is hard to do manually.

Our interactions with these organizations made us realize that offline telephony messaging systems such as Spoken Web [10] and Avaaj Otalo [11] could be used to smoothen out community interaction. These systems work off a telephony server that can pick up phone calls, and allows the caller to leave messages. Optionally, other callers can listen to these messages, reply to them, and add their own messages. Essentially these systems can enable a voice message board, which because of being voice-based, becomes accessible to anybody who simply owns a mobile phone and does not even know how to read and write. Pilot projects of these systems were used for agriculture to serve as a local Q&A forum where farmers could answer each other's questions. These projects indeed were an eye-opener on leveraging the accessibility and simplicity of mobile phones as a community interaction mechanism.

These systems are clearly also useful to allow people to simply call in and leave questions or feedback, making it much easier for the community organization to deal with the inputs. We are also enhancing these systems with SMS and an integrated community database. Our idea is that over time the system can intelligently learn different characteristics about callers, such as their profession, or their village, or specific interests in civic matters, or their level of proficiency in different topics. These can be used to send, for example, job updates to daily-wage laborers, or solicit feedback from motivated people on the ground, or track important incidents and occurrences in different areas. We have only recently started prototyping our extensions. Some interesting experiments we intend to do are around solicitation of rating feedback for message ranking, inference of expertise of callers based on their popularity, a tag-based search to browse large message lists over the phone, and crowdsourcing to transcribe voice messages.

Our field visits have revealed that offline voice applications and community databases can be quite helpful tools for any organization to engage with their communities. We will explore in future detailed nuances of this medium of communication, including to make it more accessible and to be able to mine useful information from the corpus.

IV. Content Sharing

"When minds interact, new ideas emerge" – JCR Licklider and RW Taylor [12].

We noticed that there was significant variation in the format and style of programming followed by different community radio stations. Some stations made highly engaging programs on agriculture by creating characters representing birds, earthworms, and the wind and the rain, etc, to convey information in a drama-like manner. Other stations preferred to use interviews of experts, or a narrative form in their programming. This largely depended on the background of the staff managing the radio station – whether they are from a journalism background or from music and arts, or the organization itself on whether or not it had a prior history of community engagement. We are not aware of studies about the effectiveness of different formats, but we know from our conversations that staff at different stations are definitely keen to learn from each other and experiment with different methods. This is however hard because their parent organizations are often not able to fund trips to other radio stations.

We came across similar needs for community video, and it is only natural that people running community organizations can learn a lot from each other. Content sharing can help address the issue, but poor Internet connectivity in remote and rural areas is a significant barrier. Content sharing may also be hard to do using standard web-based textual interfaces because most staff at these places are not comfortable with typing out feedback or questions. Voice-based feedback however could be the way to go. Keeping these needs in mind, we are building a content distribution network for rural areas that can be used for publish-subscribe applications, or social-networking for staff and volunteers to engage with each other.

The same system can also be used for distributing media content for public consumption. People even in low income communities are known to copy videos and music to their mobile phones, and even use Bluetooth to transfer this content to friends. Our content distribution network can be used to fetch interesting content to kiosks or other rendezvous locations in remote villages where people can come to copy content, potentially even paying the kiosk entrepreneur for the service.

We next enumerate the design principles behind our proposed system, and then outline further details.

A. Design principles

Our architecture is based on the following principles:

- **Offline access**: Flaky Internet access implies that applications should be designed upfront to work in an offline manner.
- **Delay tolerant data transfer**: Synchronous data connectivity is expensive to deploy and manage in remote areas, and requires large telecom operators to recognize the scope for revenue from the area. We instead rely on using USB keys carried by people moving between villages and cities, or CDs and DVDs that can be circulated among stations, to enable data transfer [13], [14].
- **Control-data separation**: Although high bandwidth data connectivity in rural areas is practically non-existent, the deep penetration of cellphones can at least ensure low-bandwidth GPRS or dial-up connectivity. Such connections can be used to form a control plane that can come in handy to issue content requests or perform route initializations [15].
- **Content replication**: Since the same data can be in demand in multiple locations, we include content replication and placement in the system design itself, as done in Internet content delivery networks [16].
- **Content based design**: A content based design is ideal when broadcast/multicast data transfers need to be performed across the network. We therefore consider content objects as first class entities in the system – they can be replicated, looked up in content registries, authenticated, and scheduled for delivery along specified paths [18].

We next use these principles to formulate a system design for content distribution in rural areas.

B. System architecture

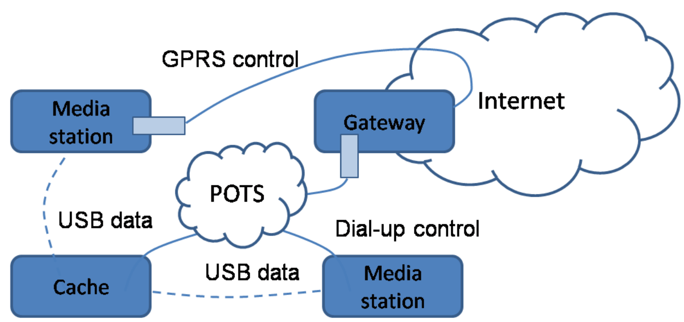


Fig. 4. System design

We begin with describing different network entities shown in Fig. 4.

- **Media station**: We use "media stations" as an alias for community radio or video stations, or any other endpoint such as a kiosk that runs applications to share content. The media station maintains a cached copy of the database or a partial index necessary to render the application even in the absence of data connectivity. And it uses a simple content push/pull API to publish or fetch content objects.
- **Gateway**: Gateways are devices that can be placed in the offices of non-profit organizations in cities, and are

assumed to have always-on Internet access. Media stations register with one or more gateways, and issue content push/pull requests over their control channel. The gateways are assumed to be aware of the network topology in their geographical neighborhood, and possibly also aware of approximate movement schedules of people carrying USB keys. They then use optimization algorithms to derive routes to move data to and from the media station and the Internet. They also keep track of multiple requests for the same content to be able to derive optimal replica locations.

- **Content lookup service**: The gateways consult a content lookup service in the Internet to obtain current replica locations. The lookup service is designed as a DNS-like service to maintain a distributed index for content objects, indexed on the URN of the content producer.
- **Caches**: Caches may run as modules on media stations and gateways, or even on independent nodes, and serve as content staging points. Whenever a node decides to hold a content object in cache, it registers the object with the lookup service. Similarly, whenever it purges an object, it unregisters the object from the lookup service. Caches also maintain a control connection with nearby gateways so that gateways can update them with content routing information. For example, the nodes can be instructed to copy specific content objects onto specific USB keys if the movement schedule of the keys is known in advance.
- **Application servers**: The application servers are assumed to run in the Internet. They maintain the master copy of databases and full indexes to run different applications. Local copies at media stations sync with the master copy by fetching updates, just as they would do to pull static content objects.

Based on this design, we are currently building a social-networking application that can function in an offline manner, and allows endusers to subscribe and browse through media collections from different stations, record voice feedback or ask questions, and publish their own content. We hope to deploy a first version of this system with a few community radio stations by December 2010.

Fig. 5 describes the same ideas in a network-stack view. Applications issue content push/pull requests which make their way to the gateway over the available control channels, and the gateway then initializes routes for data transfer over the network of caches. Applications are also responsible to periodically sync their databases, and are designed to work seamlessly in an offline manner off their local cached databases.

Interesting algorithmic issues arise if the system is to be scaled for large deployments. We are currently working on simulation studies around delay tolerant multicast of content, identification of optimal replica locations, and the inference of travel schedules of personnel. We are also engaging with a number of community organizations to gather data about movement of their staff and estimate content workload profiles, so that we can use this data as realistic parameters in our simulations.

V. NON-INTERMEDIATED SYSTEMS

The three pieces of work we described until now are essentially about assisting the intermediaries to work efficiently and ease interaction with their communities. Non-intermediated systems may seem unrealistic in this context because the people themselves do not have significant technological know-how, and the only widely available devices are low-end mobile phones which currently lack rich features. User-generated content may therefore seem like an unrealistic proposition.

An interesting scantily experimented device though is the DVD player. DVD players to browse content, and mobile phones to take videos or photographs, could actually help create an alternate **YouTube network for the bottom of the pyramid**! DVD player penetration in rural areas is almost 15%, and they are known to offer substantial flexibility in menu design, good enough to actually put a browsable Wikipedia-subset on a DVD [19]! These devices can possibly offer a lot of flexibility in presenting media content in an interactive manner. Voice-based feedback from the people can then be solicited over mobile phones, and people can even be encouraged to use newer cellphone models with better cameras to be able to contribute content themselves. Thus, DVDs containing collections of user-generated content and feedback could emerge as a convenient mechanism to distribute grassroots content right down to the community individuals. DVD distribution is also simple because informal distribution networks for Bollywood and local films already exist in remote villages, and only need to be tapped in the right places to ensure widespread dissemination.

We are currently looking into creative ways of presenting content on DVDs, for example, as information streams overlaid on a browsable map that highlights content from different geographical areas. The content need not necessarily be video content per se, but can even be a slideshow of photographs with a voice-over. This could make it easier for people to submit user-generated contributions. Voice applications for community engagement such as the ones described in the earlier sections can then be used to get feedback from people about the content. This feedback can even be incorporated in the next month's DVD to provide continued interaction on the associated topic. The feedback can also be used to determine specific topics of interest to the community, and use it to package relevant content in the next DVD.

The actual process of writing out new DVDs every month, and offloading user generated content from mobile devices, can possibly be undertaken by kiosk operators in rural areas. Many of these entrepreneurs are already involved in computerized tasks such as digital photography and the editing of wedding videos, and thus already have the required skills [20]. In addition, the content distribution network can be used to distribute content among these remote kiosks in an asynchronous manner. We are currently bouncing all these ideas off a few community organizations, and plan to do a pilot deployment in the next few months.

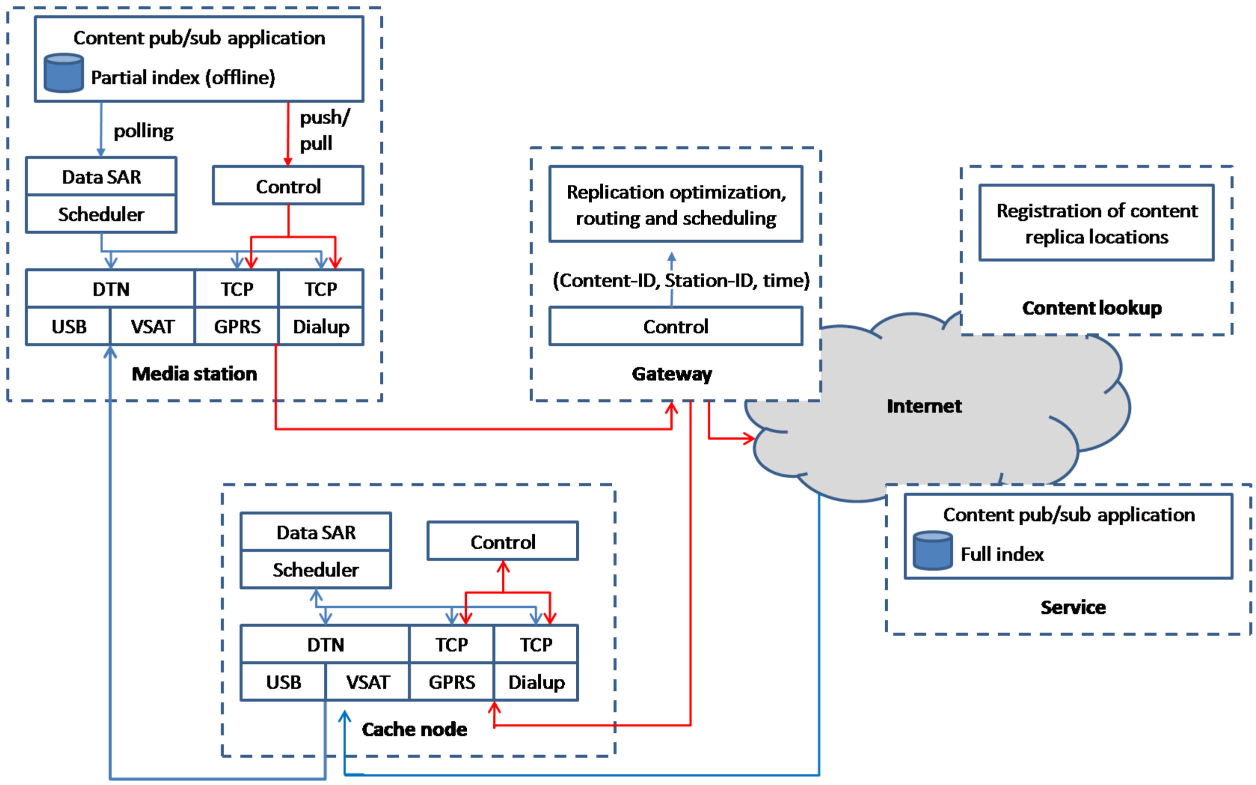


Fig. 5. Network stack

VI. Conclusions

We outlined different ways in which social media is practiced in rural and low-income communities, and described several projects and ideas from our group in which we are building technologies to help scale social media. Through our discussions, we hope to have conveyed several points that should be kept in mind when designing technologies in this context: There is obvious need for the technology to be low-cost and robust, but it is also important to understand the role of intermediaries. And finally, understanding community interactions is essential so that appropriate workflows can be suggested for people to engage with media. We will continue to explore these projects and ideas in future work.

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