CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: The Digital Backpack: Enabling Fluid Offline/Online Transitions for Remote Learners	
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Project Overview

An estimated 12 million students in the United States experience the *homework gap*–the inability to fully participate in coursework due to insufficient home Internet access. Currently, students without home Internet rely on public hotspots (at places like libraries or fast food restaurants) and will sit for hours in parking lots completing homework assignments. Students in tribal communities are disproportionately affected by the homework gap as an estimated 50-70% of tribal homes with school-aged children lack Internet access. As the 2020-21 academic year approaches and the COVID-19 pandemic continues, many schools currently plan to re-open through remote learning models. As a result, the numerous students without home Internet connectivity will continue to experience disproportionate negative impacts by the widening learning gap.

Currently, when a student without home Internet wants to get their assignments or submit completed assignments through services such as Google Classroom, they have to sit in a parking lot making sure to remember to upload and download each individual assignment in addition to answering emails from teachers, engaging in online discussion boards, and watching educational videos covering topics that they are learning about. This is problematic for many reasons, all centering around the need to remember to do many things while sitting connected in that parking lot…with catastrophic consequences for homework completion if something is forgotten. In short, the current model creates a failure-prone situation where remote learners have to spend a lot of time thinking about and planning around the connectivity of their learning environment, rather than focusing primarily on learning.

In order to address the challenges specific to offline remote learning, we envision Digital Backpack (DigiPack), an opportunistic content delivery network (oCDN) and application that supports a more flexible and automated relationship between offline remote students and web-based learning content. DigiPack will automatically prefetch content from educational services and sites (such as Google Drive, Google Classroom, Khan Academy, and Wikipedia) and push them to user devices whenever opportunistic connectivity to the Internet occurs, e.g., when users pass in and out through cell coverage. When a user is offline, they can enter their search queries related to an assignment into the DigiPack app and as soon as the device is connected to the Internet, DigiPack will fulfill those queries automatically, storing the top results on their device for later offline viewing. When a user sits at a public hotspot to attend a real-time Zoom or drives through an area with LTE, the DigiPack app will work in the background to automatically download new assignments and upload completed assignments; download new emails and send composed emails to teachers; and download new discussion board interactions and upload composed discussion board responses. Thus, Digipack allows users to “queue up” their network-connected tasks, have those network accesses fulfilled opportunistically, and can review the resulting data later.

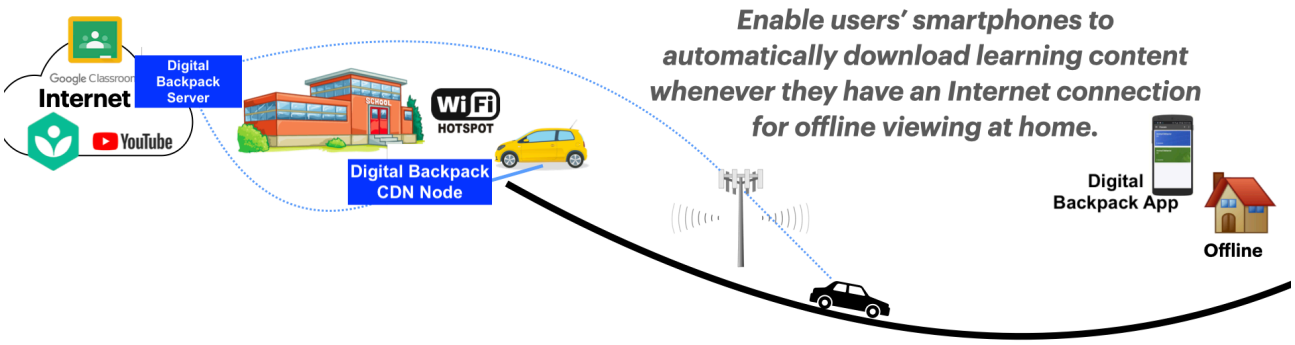

Figure 1. Overview of the DigiPack system.

Envisioned Product

Specifically, a prototype of the DigiPack system would include a mobile phone app and a proxy server. The mobile phone app would allow users to view learning content and assignments (e.g., web pages, videos, discussion boards, emails) when they are offline. The mobile app will also queue search requests, content uploads (e.g., submitted assignments), and emails and when the user's mobile device establishes an Internet connection, the mobile app will proactively (no user intervention required) upload content in this queue to the DigiPack proxy server. The mobile app will also proactively pull content that has been queued for download by the DigiPack proxy server, including new assignments, updates to class discussion boards, relevant websites for assignments, and new emails from teachers. The DigiPack proxy server will work on the user's behalf when they do not have Internet connectivity and will develop a queue of content for the user's device to proactively download when Internet connectivity is established. The proxy server will also handle the upload of content from the user's mobile device by uploading content by proxy to third party APIs.Critically, the main goal of DigiPack is to help remote learners navigate ***the online/offline transitions and provides a more casual relationship with Internet-based learning resources.***

Some features will include:

<u>The Basics</u>

- A Linux-based proxy server that:
  - Integrates with Google Classroom APIs
    - Get announcements
    - Get assignments
      - Get supplemental content to support assignments: web pages and possibly store streaming videos for offline viewing?
    - Get grades
  - Integration with Google Search
    - Enable stored search queries to be automatically posted when a device has Internet connectivity
    - Store top query responses to the user's device for offline viewing
  - Manages necessary OAuth credentials that are required for a user's "account/identity" to access Google Classroom services
  - Provides a REST API over which the DigiPack mobile app is able to upload and download content
  - DigiPack server pre-fetchies content on a user's behalf so that when opportunistic connectivity is established, new content is immediately ready to be pushed (or pulled) to the user's device
- A mobile phone app that:
  - Automatically uploads finished assignments, discussion board posts, Google queries, and classroom communications (emails and Google Classroom messages) when the mobile device establishes Internet connectivity
  - Automatically downloads new content (e.g., messages, queried content, Google calendar dates, web pages) when the mobile device establishes Internet connectivity
  - Displays content delivered from the DigiPack proxy server when the user is offline and enables the user to interact with content appropriately either in the app or in other apps installed on the phone,

e.g., view locally stored web pages in a Web Viewer in the app and opens Google Documents in the Google Doc app
    - Uses a "first-come, first serve" prioritization scheme for scheduling uploads
    - Uses a "last-in, first out" prioritization scheme for scheduling downloads

Unique and Key Features to Make DigiPack Truly "Usable"

- Proxy server
    - Able to adjust its download queue settings to support user preferences that have been set in the settings and to ensure that resources for assignments are queued together (e.g., all necessary files and resources for Assignment 1 are queued together so that it is more likely that an opportunistic transaction will have them all downloaded to the mobile app in the same transaction).
    - Users are able to adjust the scheduling priority for the download queue
- Mobile phone app
    - Developed for cross platform environments (e.g., works for Android AND iOS)
    - Users are able to adjust the scheduling priority for the download and upload queues based on date assigned, date due, assignment criteria (e.g., points available), or content type (e.g., prioritize
    - Allows users to specify settings for asynchronous Google queries (e.g., this query is relevant UNTIL this assignment has been submitted; after that, it is irrelevant and should be removed from the upload and download queues)
    - Allows users to tie Google search queries to specific assignments
    - Provides users with feedback on which assignments, queries, and communications that are in the upload queue have been serviced
    - Provides users with a summary of the download queue (and how much has been downloaded to their device) so that users can decide if they want to stay at a hotspot for a longer period of time

Stretch Goals: Cool ideas for an exceptional DigiPack System

- Proxy server
    - Tracks queries that other users make for assignments and prefetches the most commonly searched web pages and places them near the assignment content in the download queue
    - Uses natural language processing to figure out likely search queries that might yield useful resources for a particular assignment
- Mobile phone app
    - Works as a web app as well as a mobile phone app (think: support for Chromebooks)
    - Provides an estimate for how long each download and upload in the queues will take based on current network connectivity metrics and lets the users re-prioritize content items in the queue to ensure a greater completion rate
    - Users can rate the prefetched content that the server provides, which can be used by the server to hone its recommendations for future content

Societal Impact:

It is anticipated that the development of DigiPack will be extremely useful to many students who live in homes that lack Internet connectivity (12 million students in the United States!). This system will help address a gap that has significant educational and economic implications, particularly in rural and tribal communities where the homework gap is most prevalent and pernicious. In particular, we hope that this implementation of DigiPack can be eventually be used In practice with the rural schools she partners with in Navajo Nation, Santa Clara Pueblo, and rural Fresno County.

Knowledge, skills, and expertise required for this project:

- Mobile app and web app development skills. While a mobile app (Android and iOS) is the key platform that should be supported, many students use Chromebooks, so DigiPack should be able to support a web application interface as well.
- Basic understanding of how web proxies work
- Basic understanding of delay tolerant networking and asynchronous communications/interactions

- Basic understanding of recommendation systems work
- Basic web application development skills. A simple web app “back end” will need to be built to serve as the “other end” of the data prefetching and delivery process, i.e.,

Equipment Requirements:

- There should be no software required other than a development platform and software/tools freely available online
- Android phones (Available via CANIS Lab)

Software and other Deliverables:

- The mobile app + proxy server product as described above, deployed and tested successfully with representative data. Must include a complete and clear User Manual for configuring and operating the software.
- A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. This document should provide a strong basis for future development of the product.
- Complete professionally-documented codebase, delivered both as a repositoty in GitHub, BitBucket, or some other version control repository; and as a physical archive on a USB drive.
- At minimum, an Android and web application user interface for DigiPack that is ready for extensive user testing