CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: Digital Backpack: Opportunistic Learning Content Management System	
Sponsor Information: CANIS LAB COMMUNITY-AWARE NETWORKS & INFORMATION SYSTEMS	**Dr. Morgan Vigil-Hayes, Assistant Professor** Community Aware Networks and Information Systems (CANIS) Lab School of Informatics, Computing, and Cyber Systems Northern Arizona University morgan.vigil-hayes@nau.edu

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 near available WIFI access points completing homework assignments. During breaks from in-person schooling, either due to summer breaks, or during remote schooling emergencies like COVID, students who experience the homework gap are especially at risk of falling behind and experiencing disproportionate negative impacts by the widening learning gap.

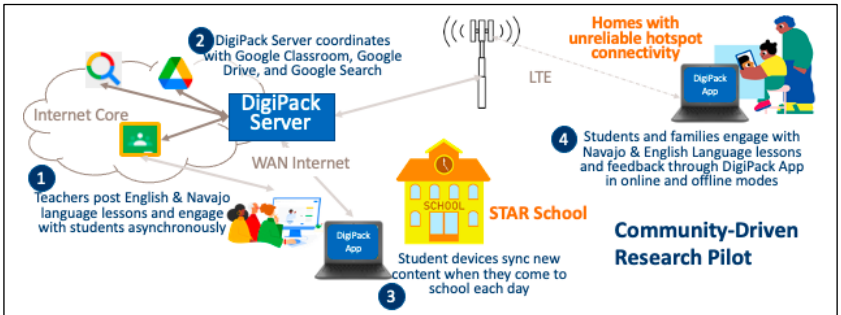

Figure 1. Overview of the current plans for piloting the Digital Backpack.

In order to address the challenges specific to offline remote learning, the CANIS Lab and a previous Capstone team implemented the 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 automatically prefetches content from educational services and sites (such as Google Drive, Google Classroom, and Wikipedia) queuing it up for distribution to remote end users. When those end users and their devices pass into or through service areas, e.g., when users pass in and out through LTE cell coverage, or sit near a WIFI hotspot, DigiPack opportunistically pushes content to user devices. Conversely, when a user is working offline, they can enter their internet search queries related to an assignment into the DigiPack app, these are queued up, and as soon as the device is connected to the Internet, DigiPack will fulfill those queries automatically, storing the top results on the user's device for later offline viewing. Thus, Digipack allows users to "queue up" their network-connected tasks, have those (ingoing and outgoing) network access requests fulfilled opportunistically, and can review the resulting data later.

The Digipack has been successful as a proof of concept, but there are some major opportunities for extensions based on feedback from teacher and student software testers. These new modules will enhance the DigiPack's ability to be proactive on behalf of student and teacher users by leveraging usage data and techniques from natural language processing, temporal analysis, and social recommender systems.

Envisioned Product: An oCDN-based remote learning environment

We envision the DigiPack 2.0 product as a new layer of functionality, GUIs, and features that will be built on top of the existing DigiPack1.0 communication core. It will leverage the oCDN communication features provided by that core to construct a complete and flexible online learning environment on top of this core, providing a powerful way for teachers to organize coursework; distribute assignments and links to resources to complete them; and – most of all – to provide a smart opportunistic content management substrate for optimizing internet access needs related to coursework. Specifically, we envision a secure, well-designed Web2.0 web application that provides some of the following key features:

The Basics

- A Linux-based proxy server (builds on DigiPack 1.0) that:
    - Integrates with Google Classroom APIs
        - Allows teachers to provide keyword tags to assignments to facilitate automated search
        - Performs an NLP analysis on tags and assignments to determine topic(s) associated with content
    - Integration with Google Search
        - Uses generated topics to launch intelligent searches for educational content on the user's behalf
        - Stores top query responses to the user's device for offline viewing
- A progressive web app for students (builds on DigiPack 1.0):
    - Provides an interface that allows students to rate returned web pages from Google search based on how helpful they were for the assignment
    - Based on data collected from DigiPack app on student's device, provides student with a time series view of when they are likely to have a connection to the Internet (based on previous connectivity information)
    - Syncs ratings with server when Internet connectivity is available
- A progressive web app for teachers (builds on DigiPack 1.0):
    - Allows teachers to provide keyword tags to assignments
    - Allows teachers to rate websites that are returned through an automated Google search using NLP
    - Provides teachers with a time series view of when each student is likely to have a connection to the Internet (based on timestamps on the DigiPack server)

Unique and Key Features to Make DigiPack Truly "Usable"

- Proxy server
    - Tags prefetched websites with ratings from students and teachers
- Progressive web app (students)
    - Uses time series analysis to show students predictions of when their next available Internet connection will be available based on previous data of connectivity
    - Web search result content is fetched from server in a priority scheme based on recommendations and rankings from other students and from teachers
- Progressive web app (teachers)
    - Flags students who have not submitted work based on predicted connectivity periods

Stretch Goals: Cool ideas for an exceptional DigiPack System

- Progressive web app (teachers):
    - When a student is flagged at a certain level, provide an interface that allows a teacher to send an email to the student and parent
    - When a student is flagged at a more severe level, provide an interface that allows a teacher to send a text to the student and parent

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. We hope that this implementation of DigiPack can eventually be used in practice with the partner rural schools within the Navajo Nation and Hopi.

Knowledge, skills, and expertise required for this project:

- Progressive 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 how 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
- Basic understanding of natural language processing (NLP)
- Basic understanding of temporal data analysis

Equipment Requirements:

- There should be no software required other than a development platform and software/tools freely available online
- Chromebooks (provided by CANIS Lab)

Software and other Deliverables:

- 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 repository 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
- Demo application that demonstrates features, including:
    - Ability for teachers to provide key word tags on assignments to assist DigiPack with recommending supplemental web content
    - Ability for DigiPack to examine content of assignments and tags provided by teachers and conduct searches on behalf of users before they even begin looking at assignments
    - Ability for users to rate the returns of search results (both those initiated by humans and those initiated using NLP)
    - Ability for DigiPack to predict resources that should be fetched for users based on highly rated content that has been fetched for other users
    - Ability for users to exchange communications with their teachers asynchronously
    - Ability to alert teachers as to when they should reach out to students based on temporal patterns of usage (e.g., "you haven't seen an update from Jane Smith in 4 days—do you want to send a text to parents to check in?")