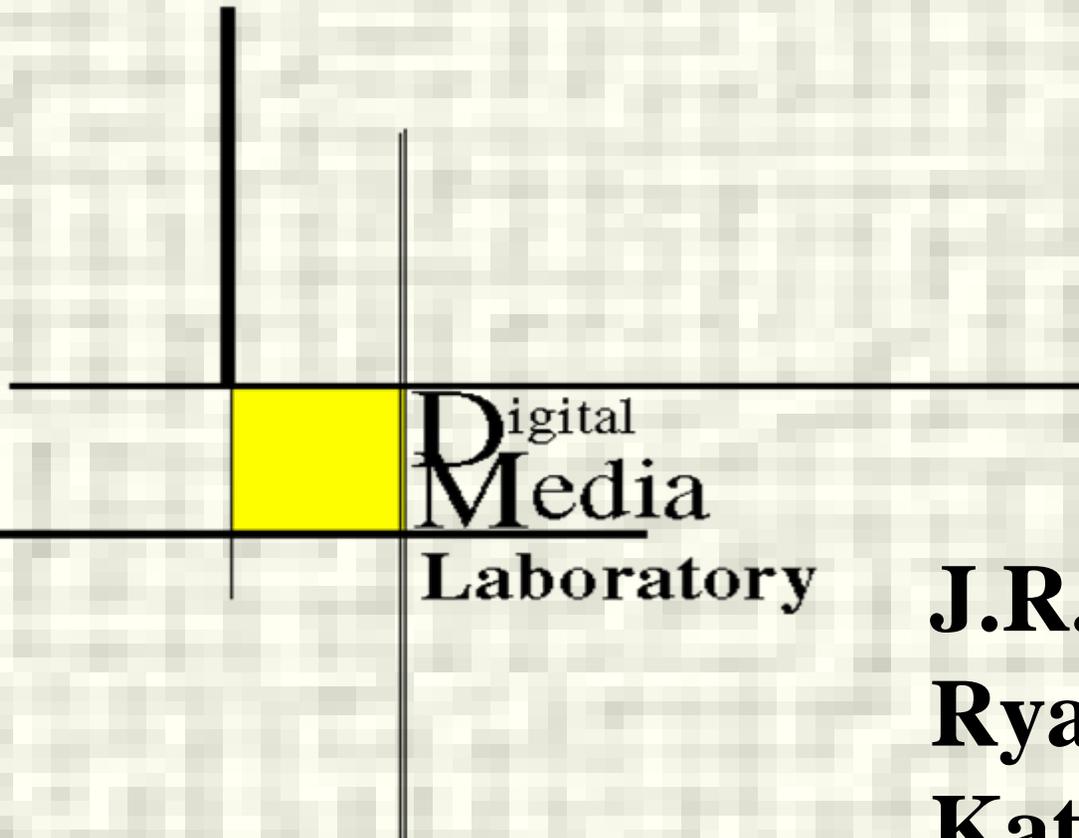# Technical Aspects of a System for Teaching Aboriginal Languages Using a Game Boy
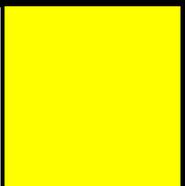
Digital Media Laboratory

J.R. Parker

Ryan Heavy Head

Katrin Becker

What's the Plan?

Games are thought of as a waster of vast amounts of time for students. Homework does not always get done.

Why not make the game the homework?

Intrinsic Motivation (Malone) – students play the game because they are keen, work harder on tasks that interest them.
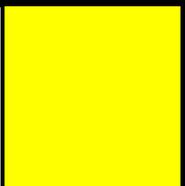
What to teach?
Native Language

One of the most important aspects of any native culture that needs to be taught is the native language.

Many aboriginal languages are endangered.

Are there thoughts that you can't think in English? Can you think them in Blackfoot?

I'powahsin

Preliminary data from the reserve indicates that the young band members play video games, and use Playstations and GameCubes like non-natives.

A survey is now being administered to gather details on these matters, and these data will be published.

The game we are building is called ***I'powahsin* (speak)**
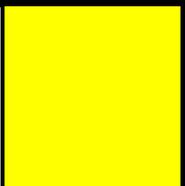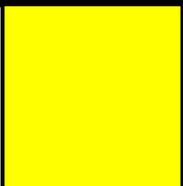
Basic Design

The idea underlying the game is that of a **quest**, a common theme in both Blackfoot stories and in video games

Instructions will be given to the player in the Blackfoot language at specified points along a predefined route through the game world.

If the player does not comprehend the instructions, then the next sub-goal in the sequence can't be achieved.

Design (continued)

1. Instructions for the player to follow are given in the language to be learned

2. A translation can be requested, which costs points.

3. Successfully following the instructions implies language understanding at some level, and game points are awarded.

4. Failing to follow the instructions costs points, and forces the game to accommodate the new situation by either starting over or creating a new set of instructions using the new situation

The Narrative - Essential

To accomplish the research goals, we must Use a Blackfoot narrative.

It was constructed by a small group of Blackfoot scholars on a reserve in southern Alberta.
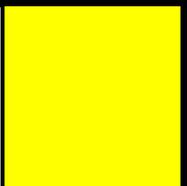
Narrative …

Characters:
Maanikapi (bachelor) loves
Iikitsiwaakii (beautiful-woman)
        daughter of
Omahkínaa (old-man)
Saahkinaa (young-man), friend
Naatoyiitapi (balanced-life), a holy man

Narrative …

The Game Boy – What sort of computer is it?

16.7 MHz 16/32 bit ARM7TDMI processor

Display is a 2.9" LCD with a resolution of 240x160 pixels and a colour depth of 15 bits, (32768 colours, 38,400 pixels)
memory is 32 Mb without bank switching to the Flash memory card.
A typical Flash game memory card is 256 Mb

Game Boy Technology

All activity is memory mapped (like old PDP 11 and VAX machines).

So: drawing a pixel or playing a sound Involves writing to special memory Locations (registers).
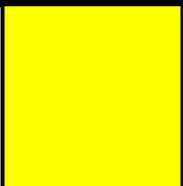
Sound

Original Game Boy only allowed synthesis.

GBA has a DAC, so it can play 'sound files'. Need this for speech.

GB has no file system – 'audio files' are coded as C/C++ Declarations, initializing an array to the sound data.

int sound1[1253] = {0125, 0111, 0173, 0653, 0552, …

These are created by a secondary utility, given a WAV.

saddr

FIFO A
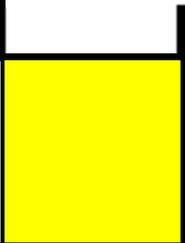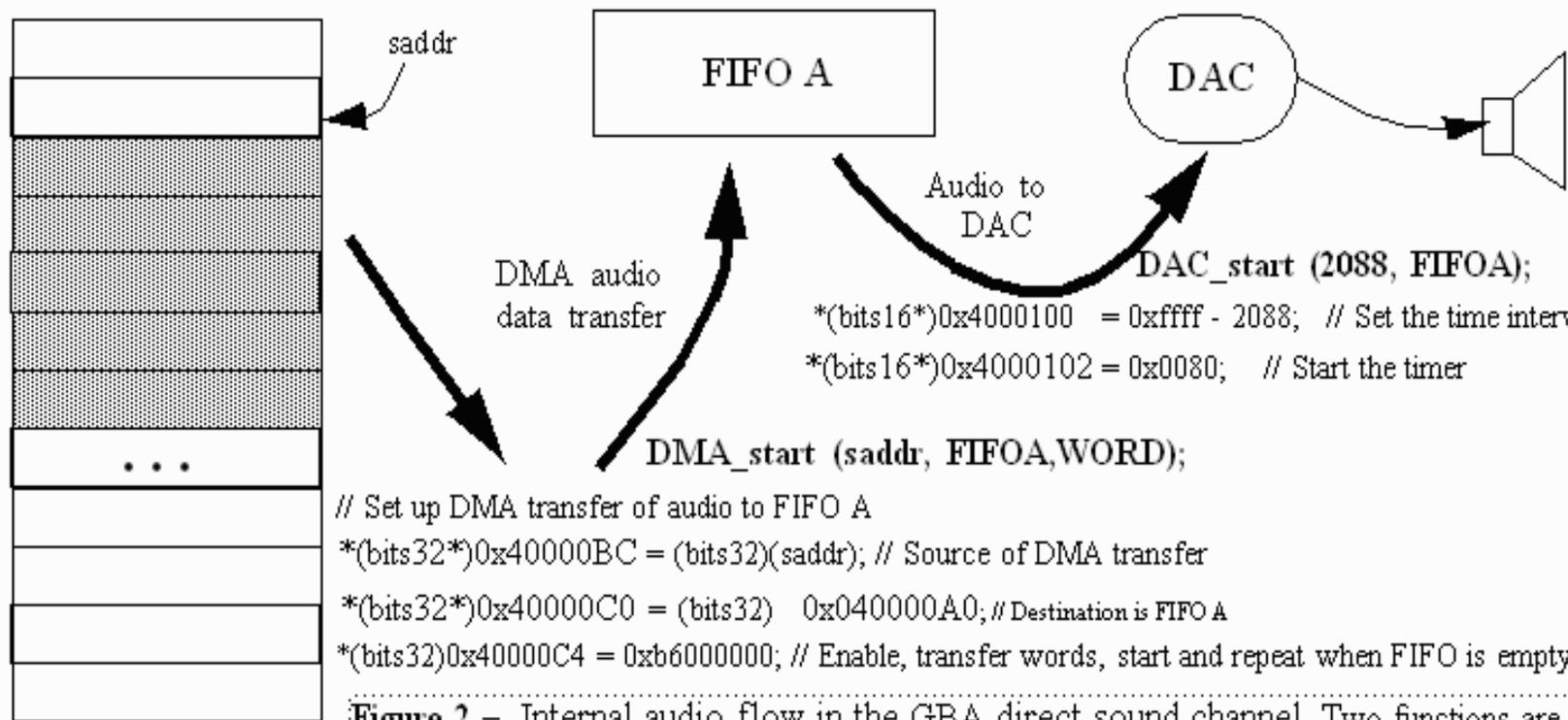
DAC

Audio to
DAC

DMA audio
data transfer

DAC_start (2088, FIFOA);

(bits16)0x4000100 = 0xffff - 2088; // Set the time interval

(bits16)0x4000102 = 0x0080;   // Start the timer

DMA_start (saddr, FIFOA,WORD);

// Set up DMA transfer of audio to FIFO A

(bits32)0x40000BC = (bits32)(saddr); // Source of DMA transfer

(bits32)0x40000C0 = (bits32)   0x040000A0; // Destination is FIFO A

*(bits32)0x40000C4 = 0xb6000000; // Enable, transfer words, start and repeat when FIFO is empty
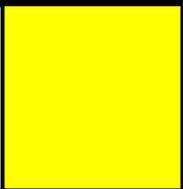
Figure 2 – Internal audio flow in the GBA direct sound channel. Two functions are defined above, and when combined form a higher level one: **play_sound (sound, fifo)**§

Memory

The Game Boy Advance has two 8-bit Digital to Analog Converters (DACs).

Each one converts a binary number into a voltage that is then sent to a speaker of headphone.

The Game Boy sound system has four
audio channels, each a sound synthesis module.
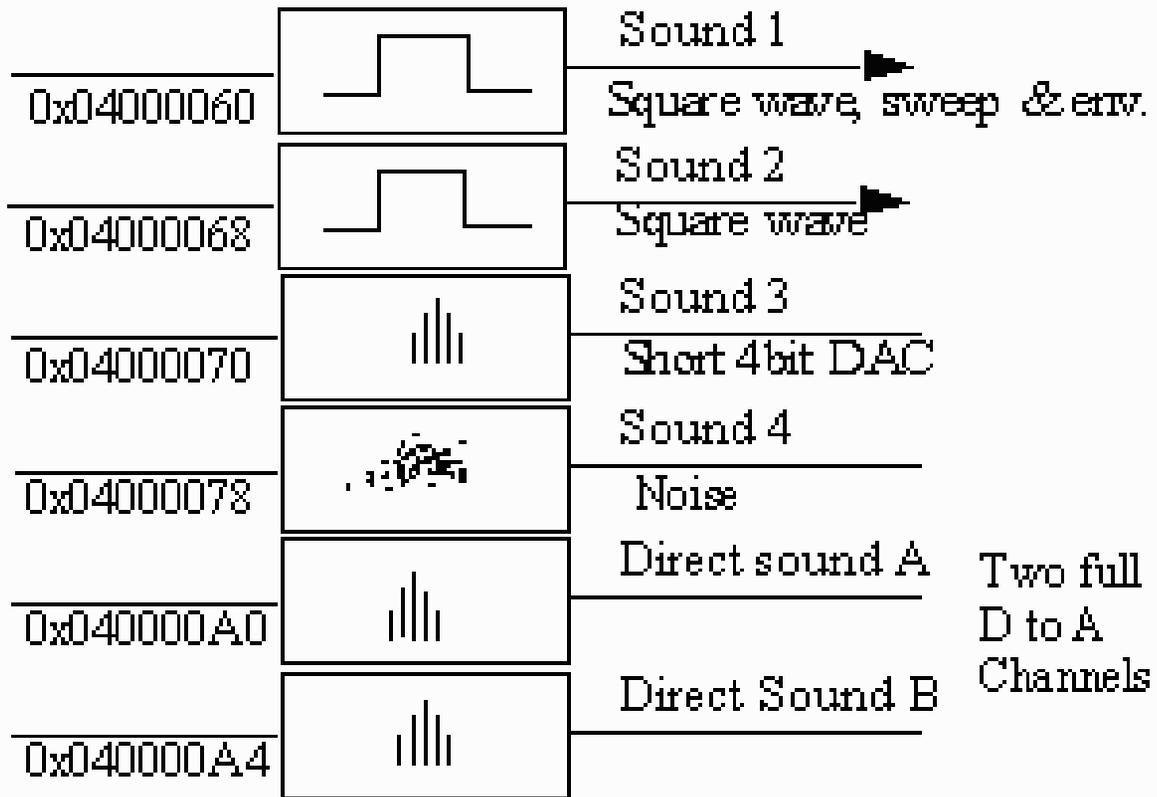The Sound 1 and Sound 2 channels are square
wave generators.

Channel 1 has a variable duty cycle,
    frequency sweep and envelope
Channel 2 has no frequency sweep.
Channel 3 acts is a 4-bit DAC that repeatedly
plays a pattern of user defined samples (4 bit).
Sound channel 4 produces noise with an
envelope function.

GBA Audio system

Address		Channel	Description
0x04000060	Square wave	Sound 1	Square wave, sweep & env.
0x04000068	Square wave	Sound 2	Square wave
0x04000070	DAC	Sound 3	Short 4 bit DAC
0x04000078	Noise	Sound 4	Noise
0x040000A0	DAC	Direct sound A	Two full D to A Channels
0x040000A4	DAC	Direct Sound B	

Direct Sound

The DAC channels, found on the GBA and above, are called the *direct sound* channels by GBA.

(Not at all connected to MicroSoft DirectX)

These can play pre-recorded and digitized sounds, like actual music and voice.

It is the direct sound that permits the GBA to be used as a language teaching tool.

Sound Architecture

- 4 Mono Channels (2 SFX, 1 Voice, 1 Music)
- Double Buffer
- 16 Khz Playback rate
- Uses timer 0 as sampling rate source
- Uses timer 1 to count the samples played in order to stop the sound

Current Mixing Routine

```
if(activeSoundBuffer == 0)
   {
    Buffer       = (u32*)SoundBuffer1;
    BackSoundBuffer  = (u32*)SoundBuffer2;
   }
  else
   {
    Buffer       = (u32*)SoundBuffer2;
    BackSoundBuffer  = (u32*)SoundBuffer1;
   }


for( i = 0; i < sound_data_size; i++ )
   {
    Buffer[pos] += sound_data[i] / MAX_NUMBER_OF_SOUNDS_MIXED;

    if( ++pos == SOUND_BUFFER_SIZE )
        {
         pos = 0;
         Buffer = (u32*)BackSoundBuffer;
        }
   }
```

AI System

The (AI) module of a computer game is responsible for

-object collisions, physics

- object management generally

- game play

The AI system is responsible for a rather complex scoring system that is based on an educated apprehension of how the language learning goals are being met.

AI system II - Rewards

Each phrase is assigned a point value
 - If a player succeeds at interpreting a phrase (indicated by successfully following the instructions contained in the phrase) they are awarded that number of points.
Each time the phrase is successfully understood, a decreasing number of points is awarded.
The implementation uses a usage count and score value for each phrase in the game. The value of the reward is

$$Se^{count-1} \text{ points}$$

 where **count** is the number of times that the phrase has been successfully understood
 S is the initial score assigned to the phrase.

AI system III - Penalties

Each word in each recorded phrase is assigned a point value, and the total points for a phrase starts out as the sum of the words.

Points are added or removed for combinations; commonly occurring combinations increase the penalty, while rare ones may not, or increase the penalty by a lesser amount.

AI System IV - Penalties

Words that have been previously understood successfully have a double penalty applied.

Each phrase increases in penalty value as a function of the number of times that the phrase has been used.

If a phrase has been used N times so far and has a basic penalty cost of P points, then the penalty for failure to understand (or cost to translate) is N*P points.

AI System V

The game AI will attempt to determine which words and phrases are difficult for the player, and can create a simple report for the instructor.

Advanced versions of the game, the AI system will test specific hypotheses (E.g. the 'word "xyz" is not understood by the player') when it determines a pattern in understanding through game play.

Visual HAM and developers/emulators