

# **A Framework for Coordination and Synchronization of Media**

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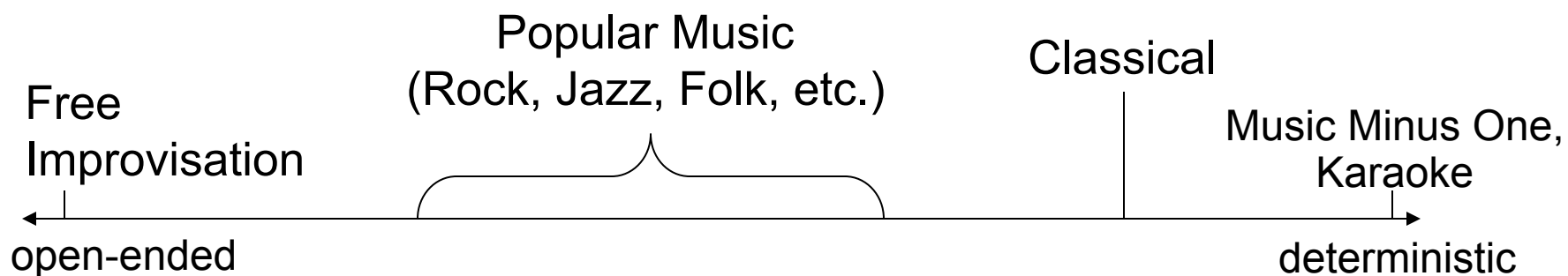
# Introduction

- Suppose you want to get together and play music ... BUT, you're missing a *bass* player.



credit: Green Day

# Human Computer Music Performance



Interactive  
Computer  
Music

(Rowe, Winkler,  
Machover,  
Geo. Lewis, ...)

HCMP

Score  
Following,  
Computer  
Accompaniment

Fixed  
Media

Our contribution today:

- (1) Coordination of sensors, players, and displays.
- (2) Using music notation as interactive medium.

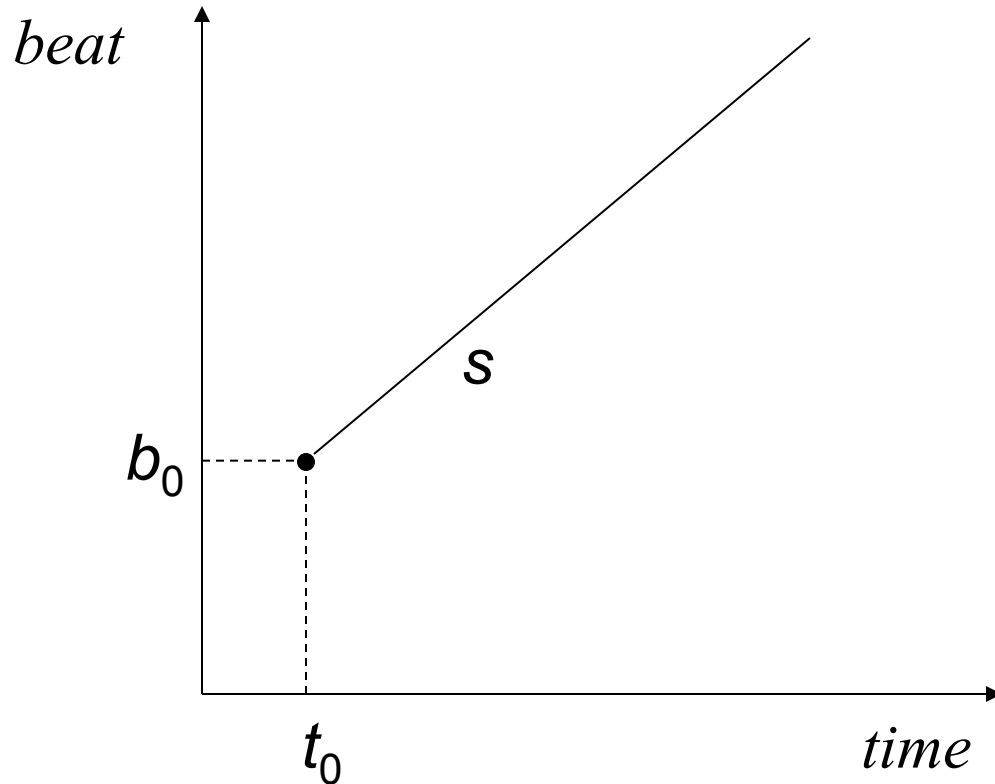
# Overview

- Introduction
- (1) Coordination based on beats and measures
- (2) Music notation as an interactive medium
- Short Demo
- Conclusions

# Part 1: Coordination of Beats and Measures

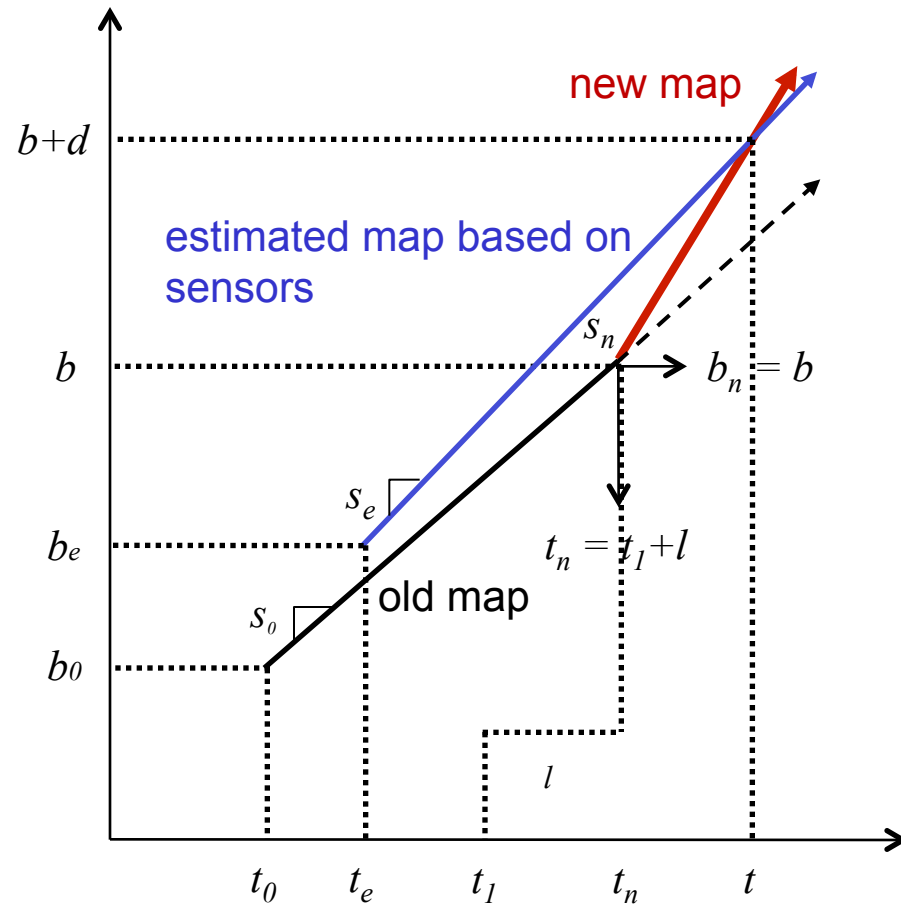
- **HCMP Systems will have:**
  - Sensors (Keyboards, pedals, touchscreens, accelerometers, machine listening, computer vision, ...)
  - Media (MIDI, Audio, Robots, Notation, Lighting control, Sequencers, Effects processors, Mixer automation, Animation, Video, Lasers, ...)
- **How do we coordinate and integrate systems?**
- **Our solution:**
  - All systems agree on real time
  - Music position is given in beats and measures - always
  - Use mapping from real-time to beats

# Mapping from Real Time to Beats

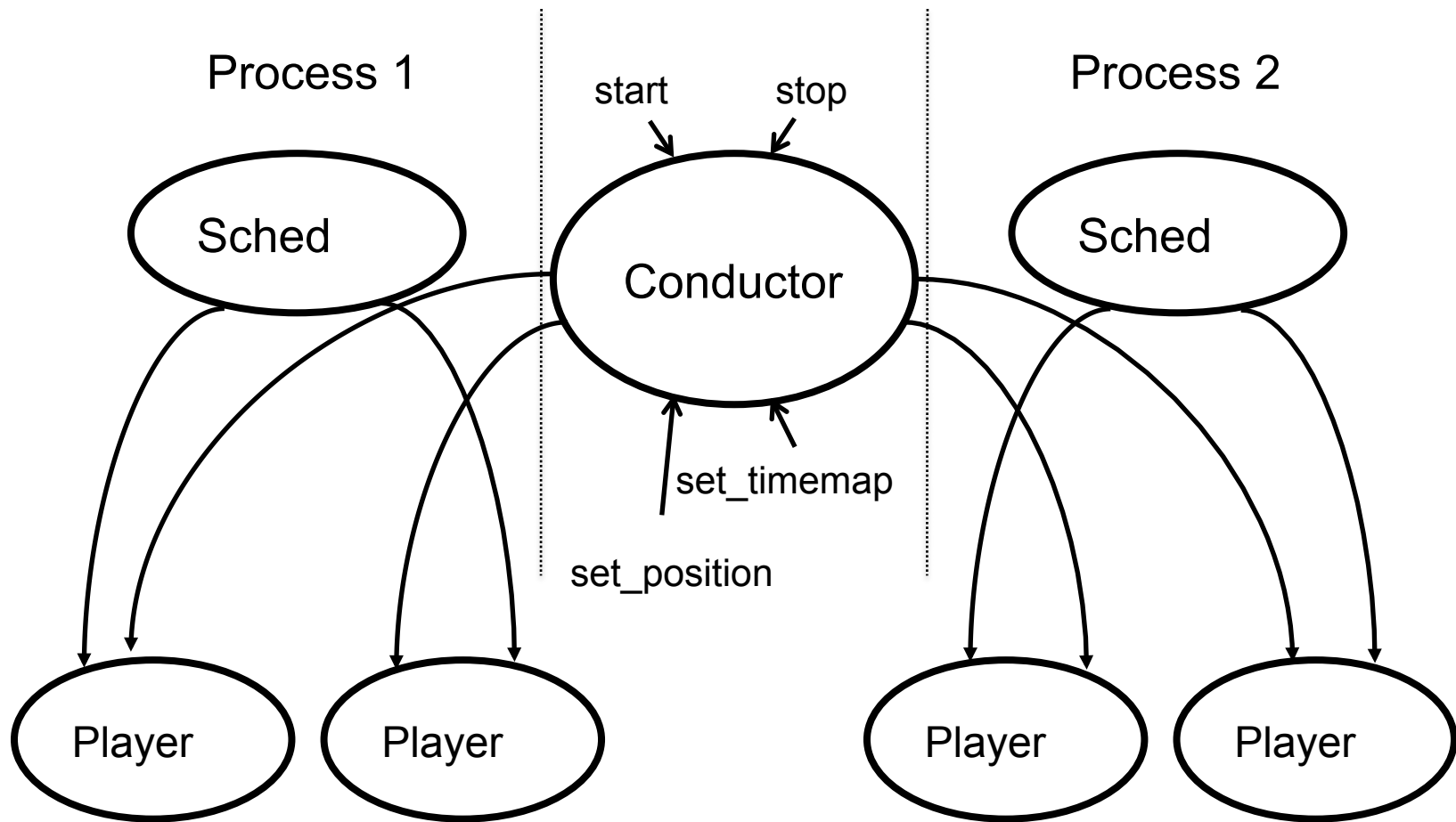


Mapping from real time to beats expressed as:  
 $(t_0, b_0, s)$

# Changing the Mapping

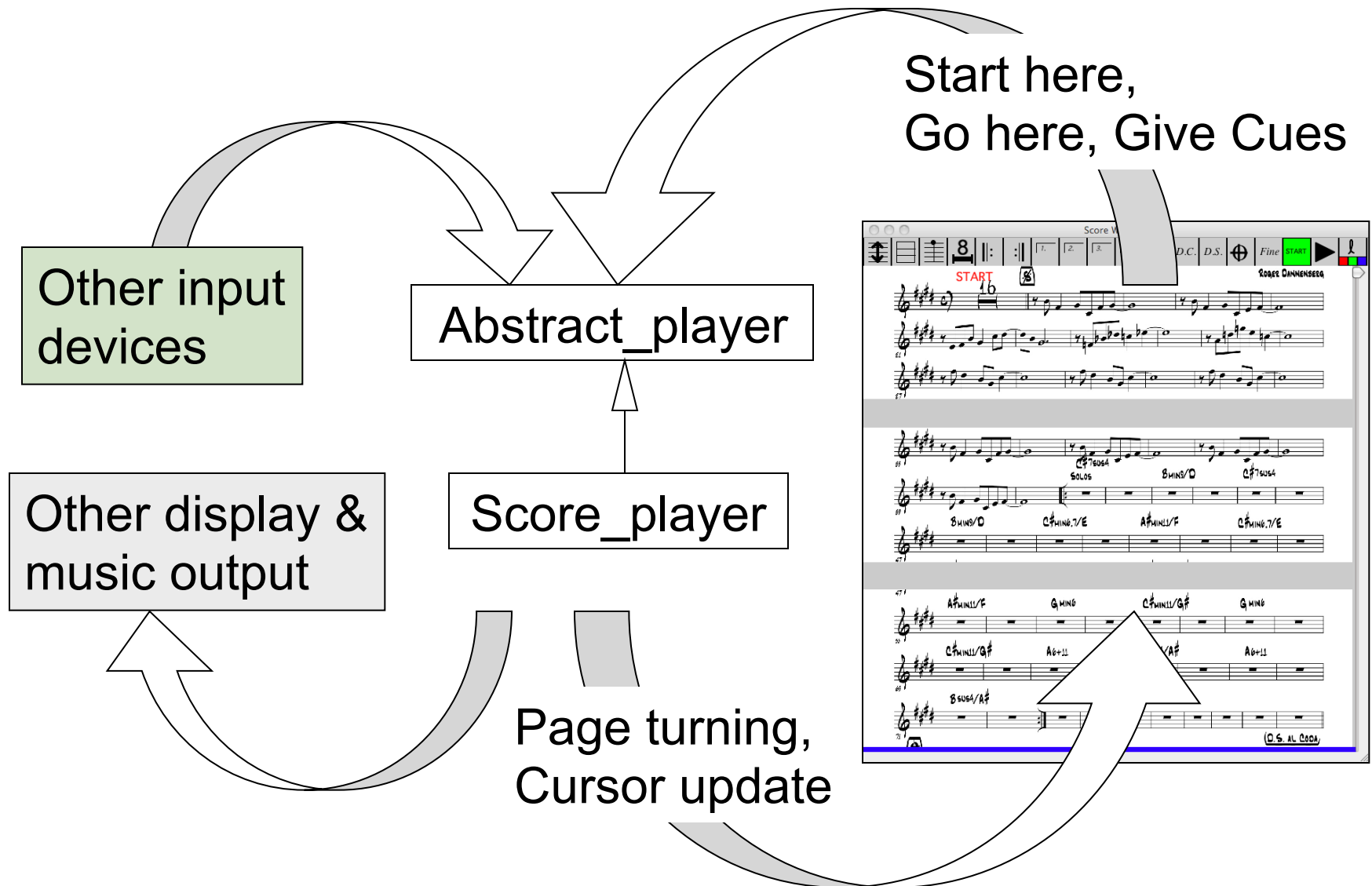


# Software: Classes and Objects





## Part 2: Music Notation as an Interactive Medium



# DEMO

# Summary

- Human Computer Music Performance: Integrating
  - interfaces,
  - automatic music listening, and
  - live performance.
- Coordination of music
  - Position measured in beats and measures
  - Many player objects are coordinated through mapping from time to beats
  - Common algorithm to smoothly update mapping
- Music notation as a user interface
  - Provides intuitive support for musical interaction

# Conclusions

- A flexible framework for HCMP
  - Open to HCI exploration, using
    - Touch screen
    - Gestures
    - Video sensing
    - Speech
    - Automatic music listening
- ... to assist in live music performance.

The End

# Agreement on Real Time

- -> Clock Synchronization
- Easily done:
  - Send request to server at local time  $L$
  - After delay  $d$ , receive "time is  $G$ "
  - Estimate server time = local time +  $(G - (L + d/2))$
- More sophisticated protocols can reduce error from  $\sim 1\text{ms}$  to  $< 10\mu\text{s}$  (if needed).
- Now we can assume all systems agree on time.

# Music Position in Beats and Measures

- Seems obvious, but ...
- Static scores with repeats, D.S., etc. vs
- "Dynamic" scores such as MIDI files are "unfolded"
- See poster with Nicolas Gold in proceedings for more.
- We will (mostly) ignore these problems for now.