MPEG-4
Structured Audio

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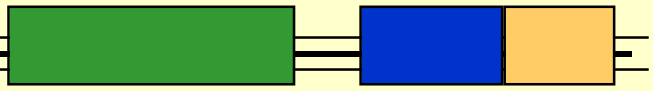
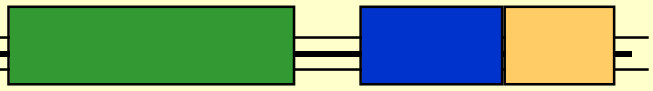


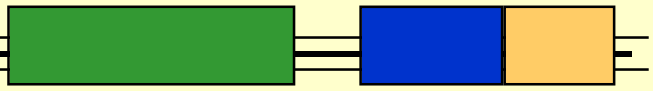
MPEG-4 Structured Audio

- General-purpose software synthesis
  - New algorithmic synthesis language: SAOL
  - Based on years of computer-music research
- Wavetable synthesis
  - Using DLS-2 format (“SASBF”)
- Streaming MIDI control
  - Also more flexible control with SASL
- TTS Interface

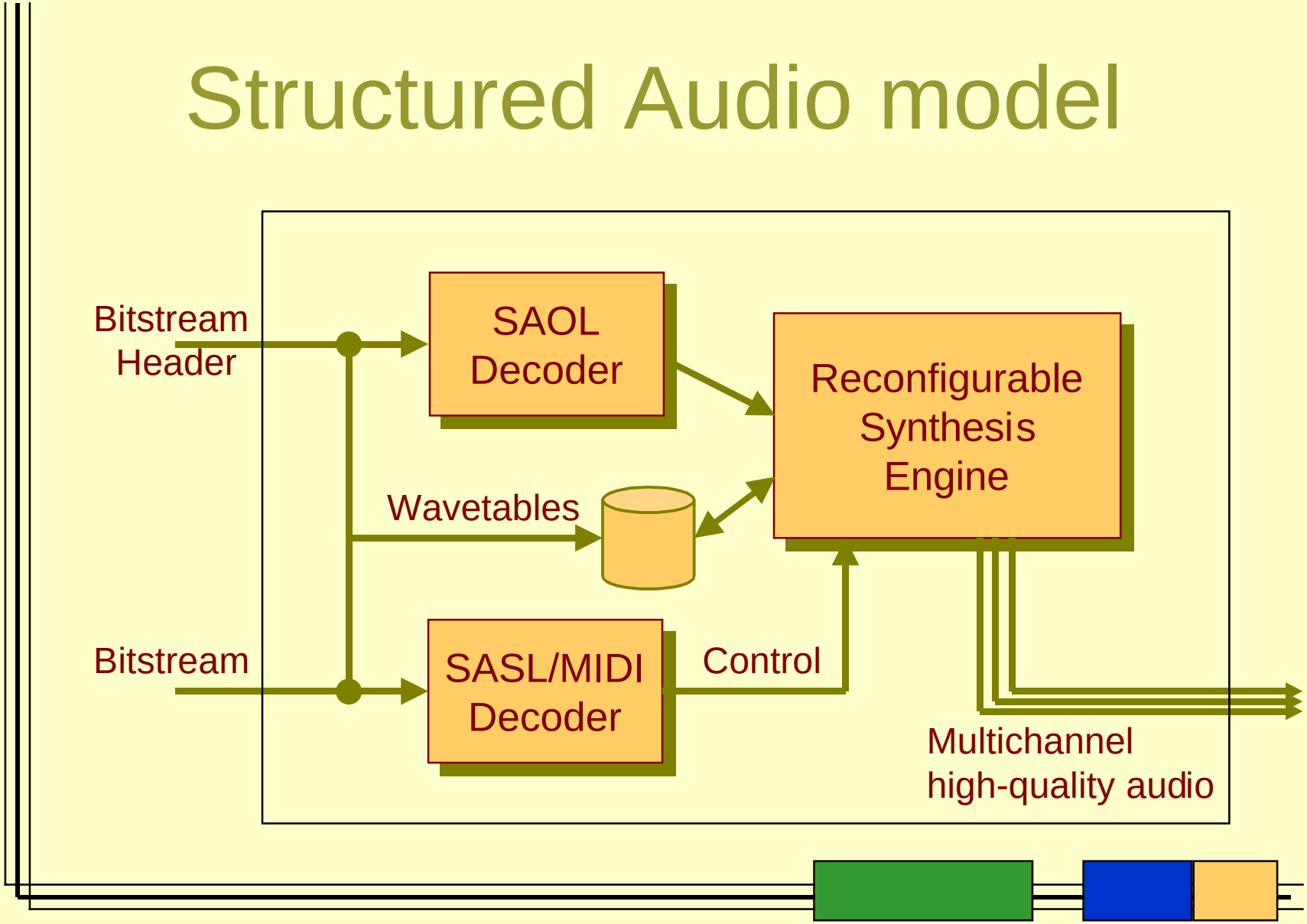


Music synthesis in MPEG?

- General-purpose synthesis not only for music
  - sound atmospheres, Foley effects, post-production, as well as music
  - very, very low bitrates
- Standardization encourages more/better implementations
- Drive forward the world of PC sound

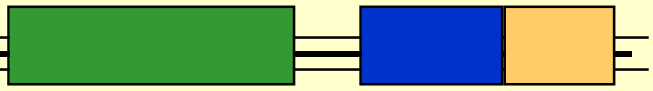


Structured Audio model



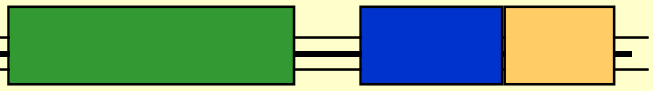
SAOL

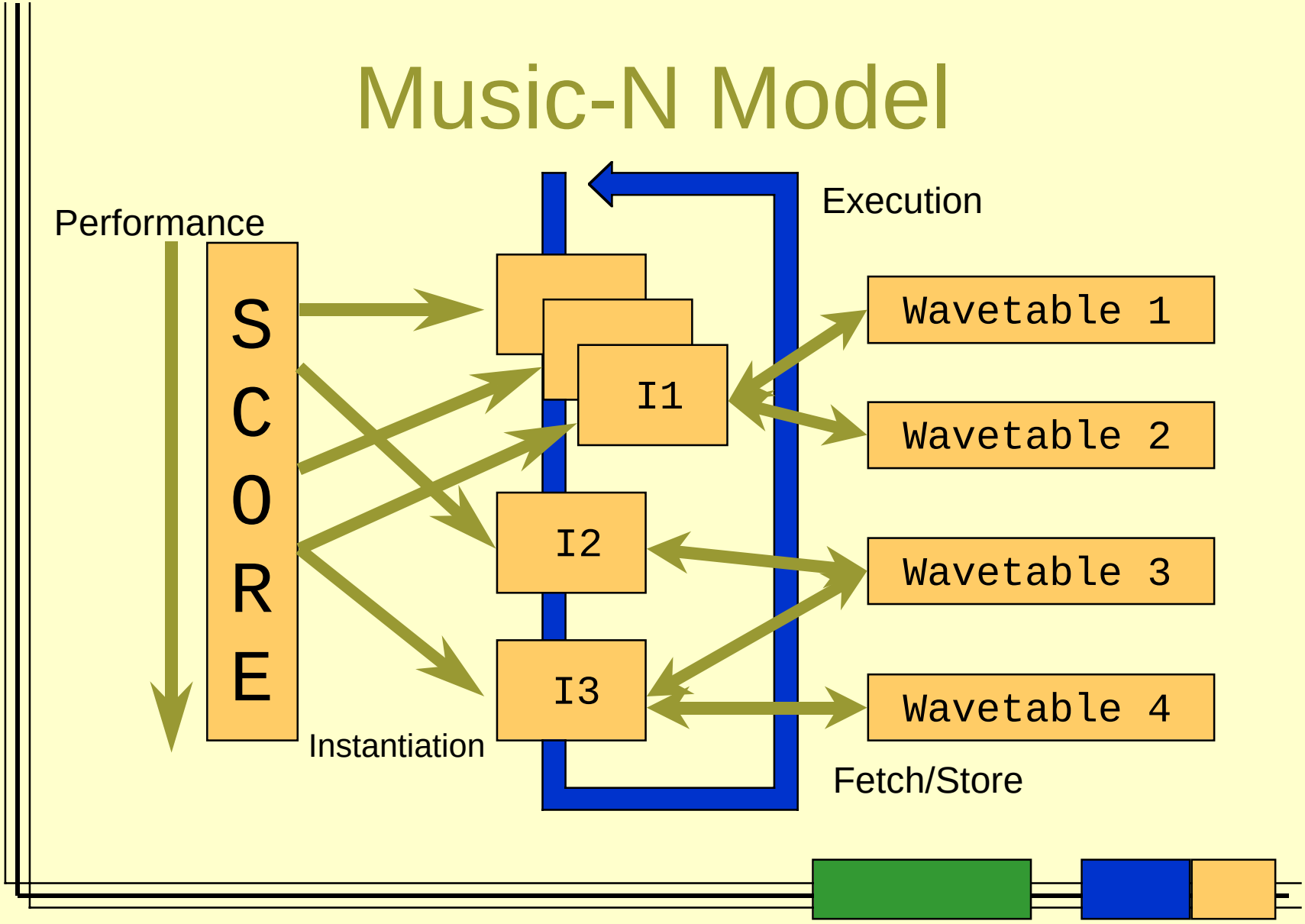
- Structured Audio Orchestra Language (pronounced “sail”)
- New “Music-N” language
- Historically derived from Csound, but redesigned from ground up
- Formal language design
- Exact sound quality
- Reference implementation (slow) by MIT



Music-N model

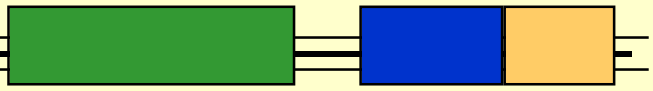
- Invented M. Mathews early 1960's
  (Earliest synthesis technology)
- *Orchestra* made up of *instruments*
- *Score* gives performance parameters
- No fixed instrument parametrization
- Instruments use built-in *opcodes*, plus arithmetic, to calculate DSP




Music-N Model
Performance
SCORE
Instantiation
I1
I2
I3
Execution
Wavetable 1
Wavetable 2
Wavetable 3
Wavetable 4
Fetch/Store

Simple SAOL instrument

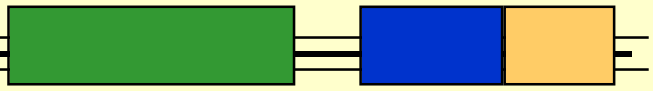
```
instr beep(pitch, amp) {
   ksig vibfreq,env;    // control signals
   asig sound,f1,f2;    // audio signals
   table vibshape(harm,128,1);  // sine wave

   vibfreq = cpsmidi(pitch) * (1 + koscil(vibshape,5)/40);
   sound = buzz(vibfreq,0,1,0.9); // noisy sound source
   f1 = bandpass(sound,500,100);  // formants
   f2 = bandpass(sound,700 + vibfreq*2,100) / 10;

   env = kline(0,0.05,1,dur,0);
   output((sound + f1 + f2)*amp*env);
}
```



Stuff built into SAOL

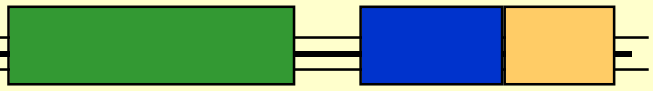
- Math functions
- Granular synthesis
- OLA FFT/IFFT
- Reverb, chorus
- Parametric filters
- “Bus routing” FX model
- Window functions
- Graceful degradation
- Karplus-Strong synthesis
- Fractional multi-tap delay lines
- Arbitrary FIR, IIR filters
- Parametric compressor-limiter
- Several noise generators
- Pitch- and time-shifting for samples
- User-extensible language model
- Dynamic note spawning
- Deep connection to SASBF (DLS-2) synthesis

and more...



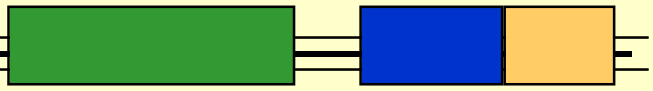
DLS-2 Wavetable Synthesis

- DLS-2 a harmonization of
  - SoundFont from E-Mu
  - Downloaded Sounds from MMA
  - One standard promotes product compatibility
- Entire DLS-2 synth embedded in SAOL
  - Write new filters/envelopes in SAOL
  - Filter MIDI input in SAOL
  - Generate new notes in SAOL



Text to Speech (TTS)

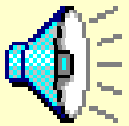
- *Interface* only
  - synthesis engine outside of standard
- Specifies
  - text
  - prosody and duration
  - facial animation cues



Example

- “Manipulator” (Michael Casey)
  - 84 seconds long (14.4 MB as WAVE file)
  - 16 KB in header
  - 11 KB in bitstream (= 0.13 kbps)
  - 100 KB in compressed samples

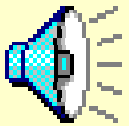
$\Rightarrow$ more than 100:1 compression,
no loss of quality



Example

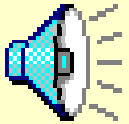
- “Xanadu” (Joseph Kung)
  - 60 seconds long (10.5 MB as WAVE)
  - 2.2 KB in header
  - 4.2 KB in bitstream (= 0.07 kbps)
  - no samples anywhere

⇒ more than 1200:1 compression,
no loss of quality



Example

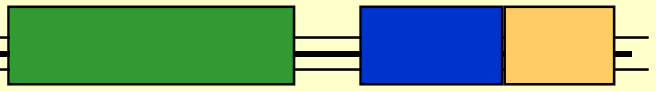
- *Le Sacre du Printemps* - Stravinsky
  (sound design by Andrew Horner)
  - 47 seconds (3 MB as WAVE)
  - 50 KB in header
  - 18 KB in bitstream (= 0.5 kbps)
  - no samples, only synthetic sound



$\Rightarrow$ more than 40:1 compression,
no loss of quality

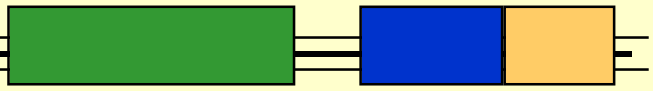
Public SA projects underway

- SAOL-to-C JIT translator
  - Soon SAOL-to-DSP, maybe SAOL-to-FPGA
- Real-time SAOL interpreter
- Web-embedded SA (like Beatnik)
- Better SAOL compiler tools
- Csound-SAOL-Csound translation
- “Visual orchestra” authoring tools



Summary

- MPEG-4
  - high-quality, low bitrate, many tools
- Structured Audio
  - streaming synthetic sound
  - very flexible, MIDI-aware, high-functionality
  - TTS interface
- International Standard
  - will be supported by many companies



For more information

- MPEG-4 Structured Audio homepage

  http://sound.media.mit.edu/mpeg4/

- Several papers in technical literature

  Multimedia Systems 7:1 (Jan 1999)

  Computer Music Journal 23:2 (Summer 1999)

  105th AES proceedings (Sept 1998, #4811)

  more forthcoming...