Channel Vocoder on FPGA

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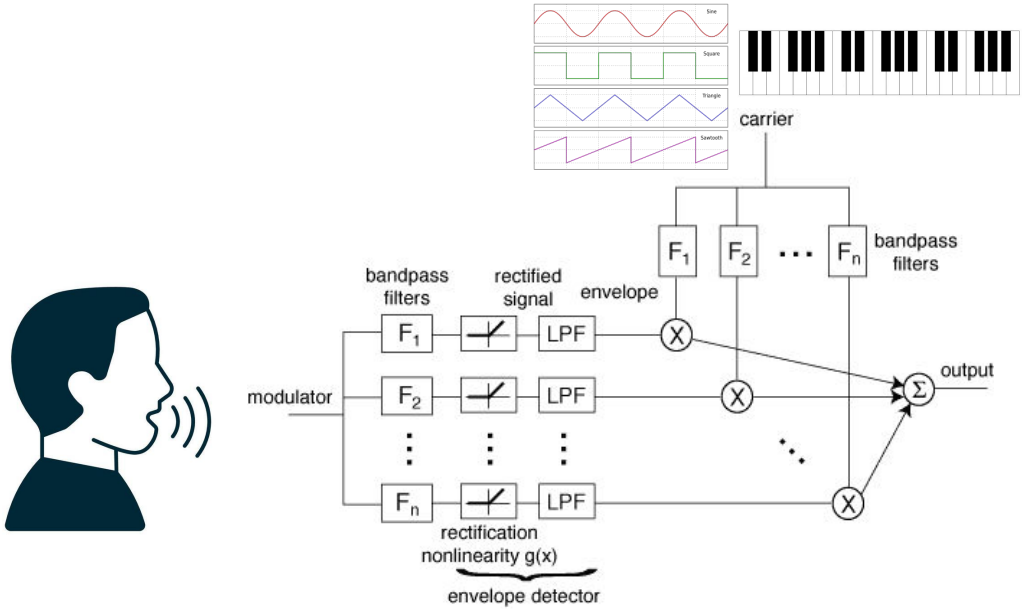
What is a Vocoder?

- Analyzes voice input, processes, then synthesizes audio output
- Applications:
  - Data Compression
  - Encryption
  - **Music Production**

How do vocoders work?

- Imposes input modulator signal (human voice) onto a carrier signal (often synthesized)



Why are Vocoders cool

- DSP is cool - used a lot in vocoding
- Music is cool, we love music
  - Many iconic songs and artists use vocoder technology

Functional Requirements

- Input
  - Audio signal serving as modulator (ie voice/instrument)
  - Controlled pitch “carrier” (ie synthesized sound)
- Output:
  - Synthesized audio signal - modulated pitch carrier

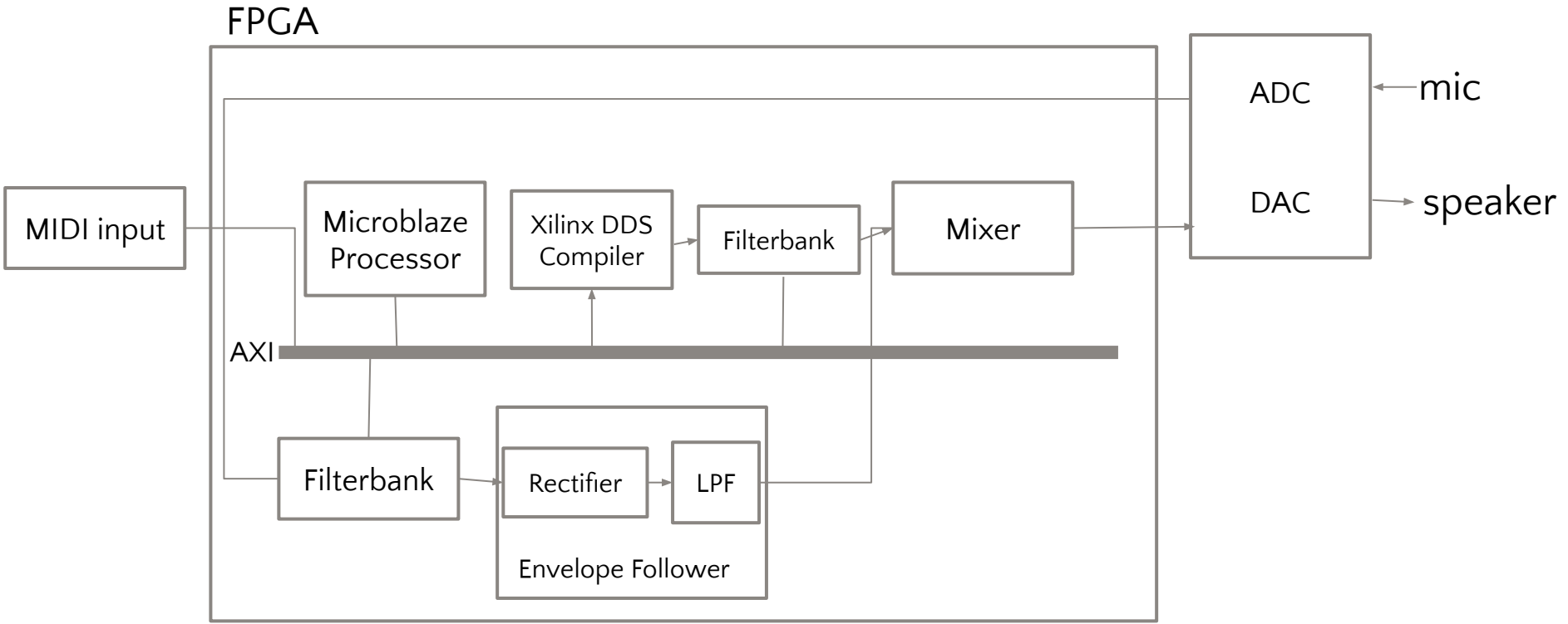
- Additional Features:
  - Carrier waveform selection
  - Pitch bending

Acceptance Criteria

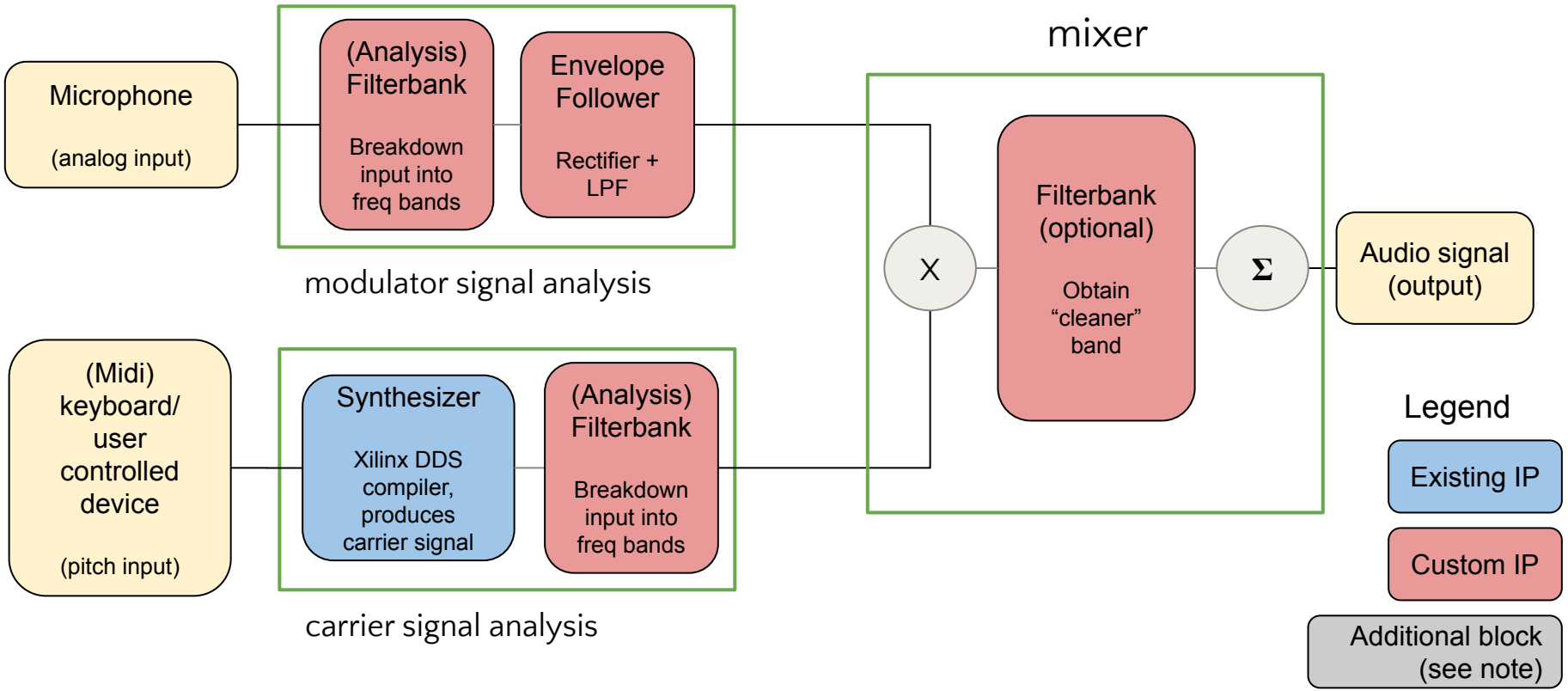
- System:
  - Impose modulator signal input onto carrier signal
  - Support at least 1 carrier waveform

- Output:
  - At least 1 selected pitch at a time

System Block Diagram



System Block Diagram



Implementation Plan

- Analog Input Handling: A microphone will be used to capture input audio
- Pitch Input Handling:
  - MIDI keyboard could be used to control pitch
  - Alternative pitch selection methods will also be explored.
- Microblaze processor:
  - Used for communicating MIDI input to Xilinx DDS Compiler
  - Could be used to change filterbank parameters
- Custom Hardware Blocks:
  - At least one custom hardware module will be developed, likely for filtering
  - Other DSP components may be implemented using Xilinx IP cores or custom-designed blocks, depending on project complexity requirements.
- Output: 3.5 mm speaker

Project Complexity

- Pmods:
  - GPIO Based **0.40 pts**
    - Rotary encoder **0.20 pts**
    - 16 button keypad **0.20 pts**
  - Other Peripherals **1.0 pts**
    - On-board audio output port **0.5pts**
    - On-board microphone **0.5 pts**
  - Potentially MIDI keyboard (**0.5+ pts**)
- Custom IP blocks
  - Filters, rectifier (**1.6+ points**)
- Total of **3+ points**

Project Testing

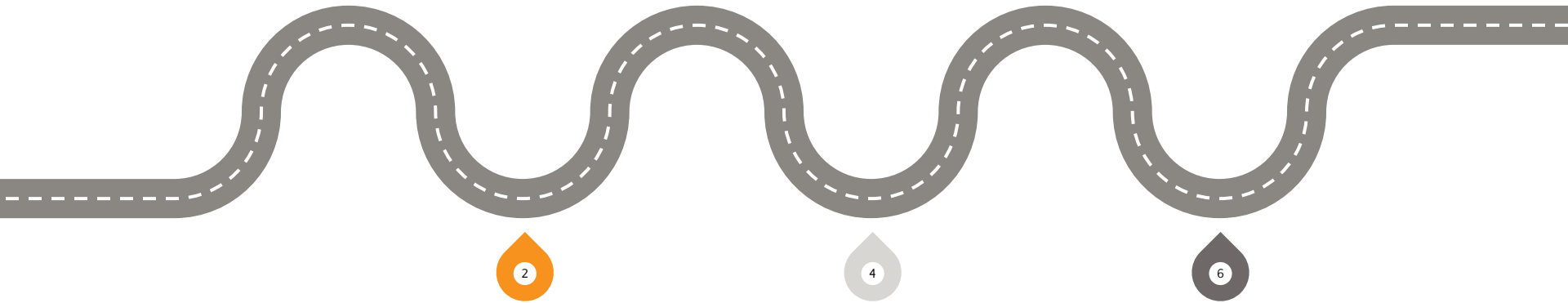
- Modular testing (milestones 2-4)
  - Filters and other IPs (behavioural simulation)
  - PMODs (physical testing for inputs)
- Integration testing (milestones 3-4)
  - Testing with integrated blocks (individual features)
    - Pitch modulation
    - Sound effects
    - Feature modulation/autotune
- Benchmark testing (milestones 5-6)
  - Meet final benchmarks and target features in full, completed project

Risks and Mitigation

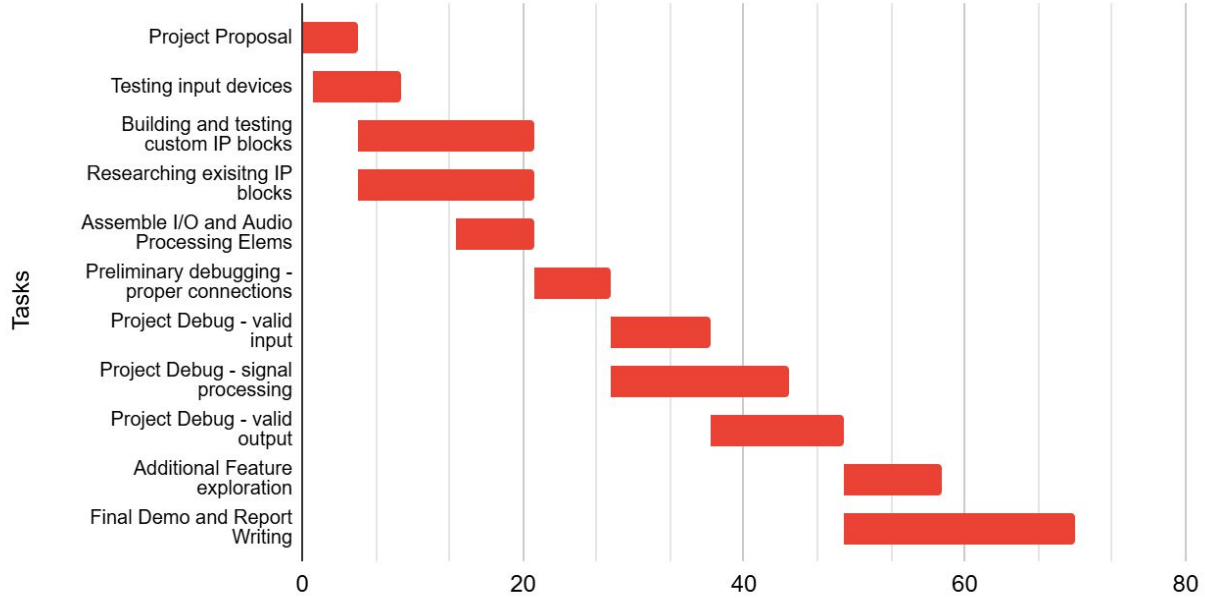
- Interfacing hardware with MIDI data
  - interfacing MIDI with hardware can be challenging
  - Relatively complex interface
  - MIDI input is optional - can use other forms of input (e.g. buttons, switches)
- Real-time DSP
  - Practical implementation on an FPGA may involve unforeseen challenges
  - Limited working experience on our team
  - May require significant additional study and trial-and-error debugging
  - Flexible with which IPs are custom - can use pre-existing IPs (as long as we meet complexity requirements)
- Bug fixing
  - Bug-fixing always takes longer than expected
  - We have allocated a buffer week for bug-fixing and complications

Milestones

1. Researching existing IPs for audio processing modules, researching I/O connections
2. Finalizing vocoder implementation details and specs, having a basic audio processing block to work
3. Showing an initial project build with roughly connected components. Most blocks should be functional independently
4. Showing functional input and processing. Hardware components should be working. Software driver should be in the debugging stage
5. Primitive vocoder working. Continue software debugging to refine certain features or add stretch goals
6. Buffer week for additional features to be implemented, or for further debug incase milestones 4/5 are pushed back



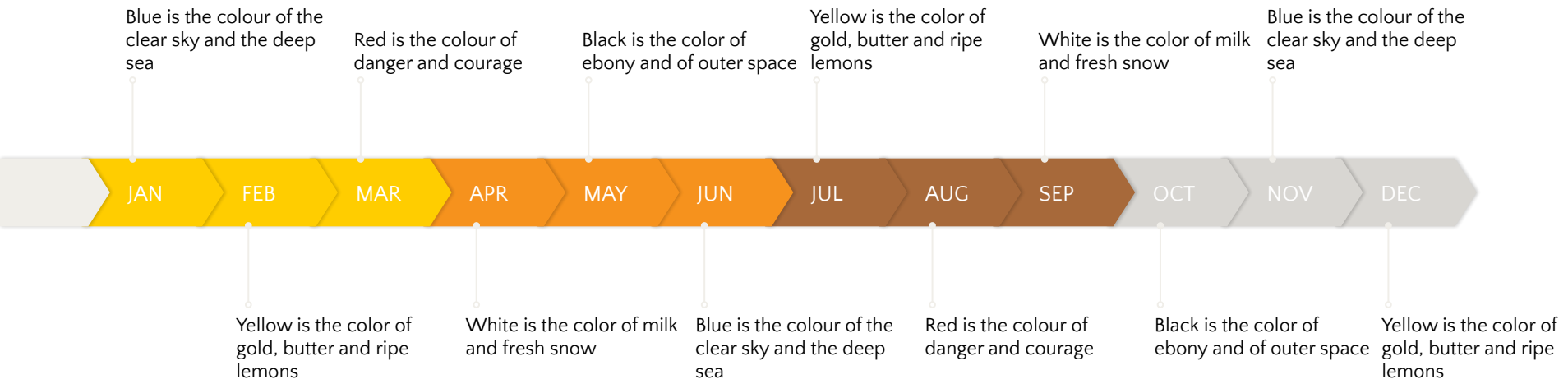
Project Timeline - SKIP



Thanks!

Any questions ?

Timeline


Blue is the colour of the clear sky and the deep sea
Red is the colour of danger and courage
Black is the color of ebony and of outer space
Yellow is the color of gold, butter and ripe lemons
White is the color of milk and fresh snow
Blue is the colour of the clear sky and the deep sea
JAN
FEB
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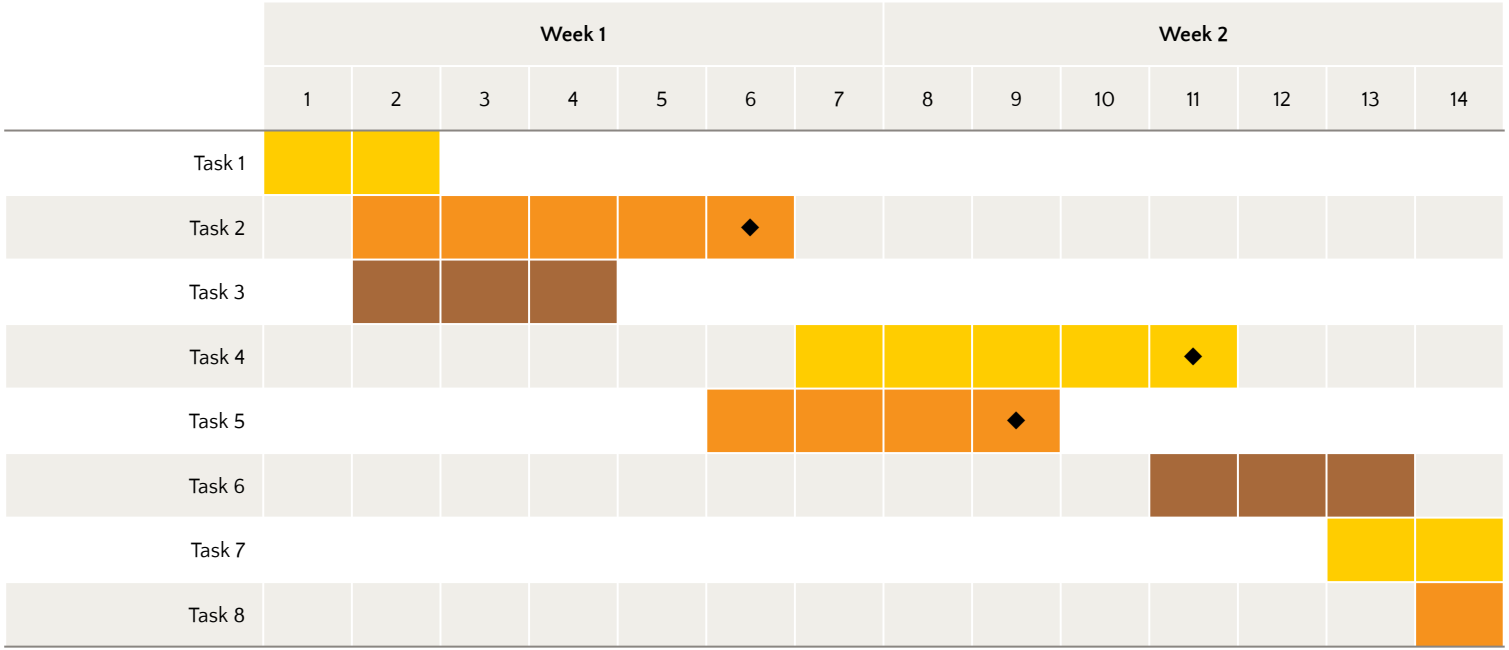
Gantt chart


Week 1
Week 2
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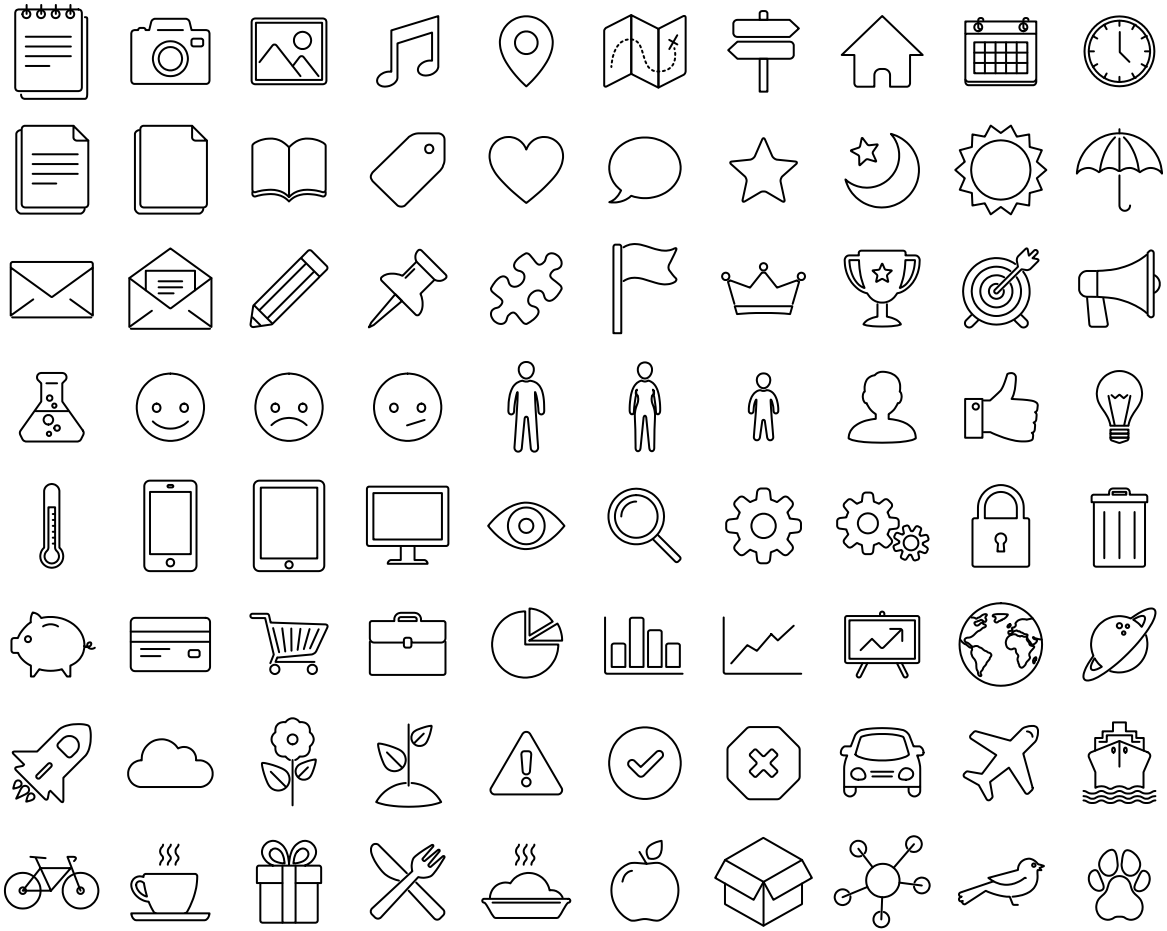
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6
Task 7
Task 8



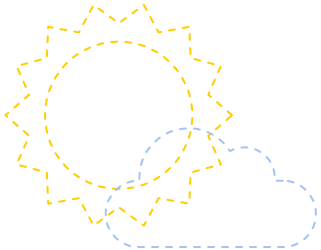
SlidesCarnival icons are editable shapes.

This means that you can:

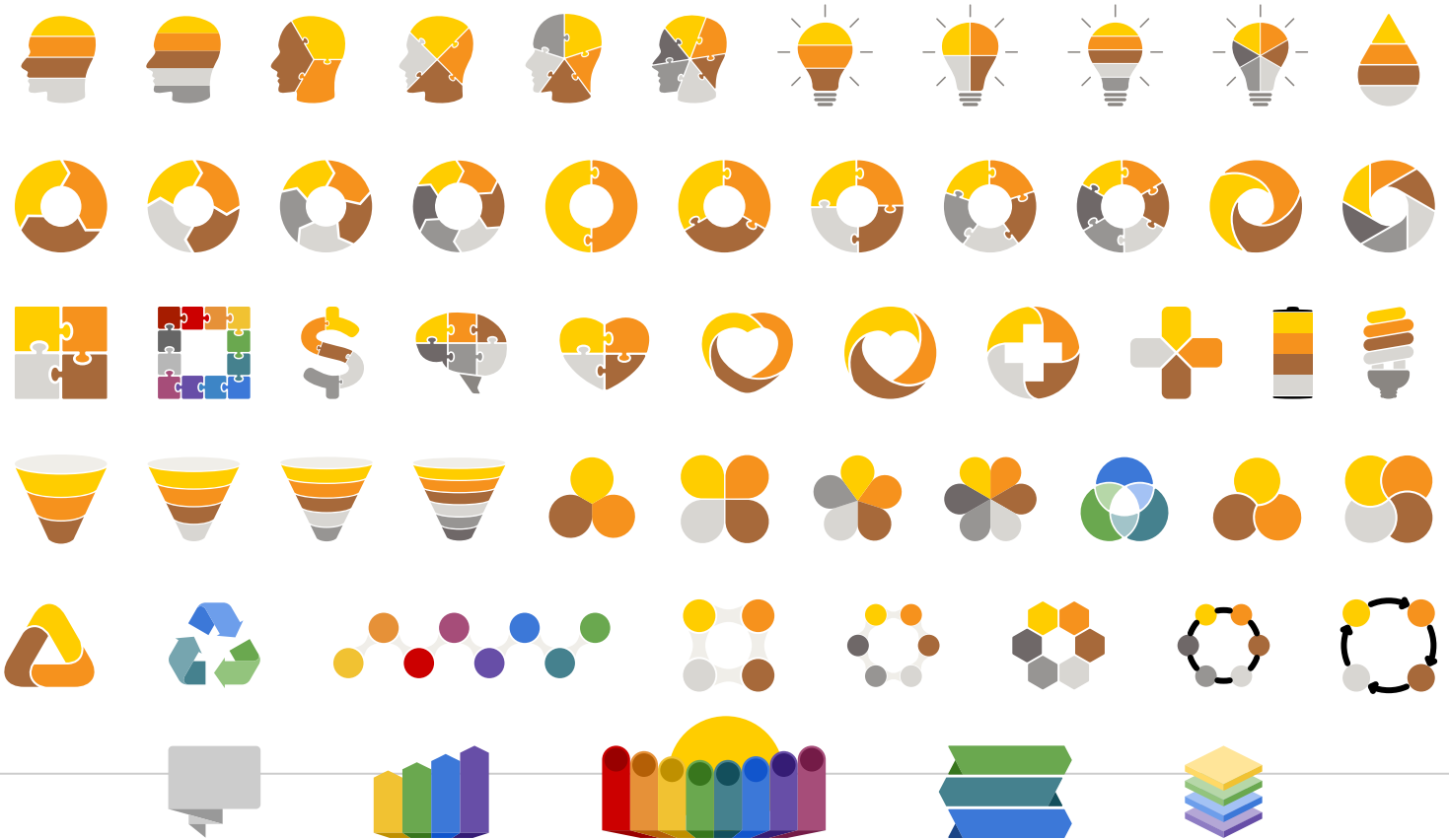
- Resize them without losing quality.
- Change line color, width and style.

Isn't that nice? :)

Examples:



Diagrams and infographics



Now you can use any emoji as an icon!
And of course it resizes without losing quality and you can change the color.

How? Follow Google instructions
https://twitter.com/googledocs/status/730087240156643328

and many more...