FOP Away Day 2007
Scalable Functional Reactive Programming

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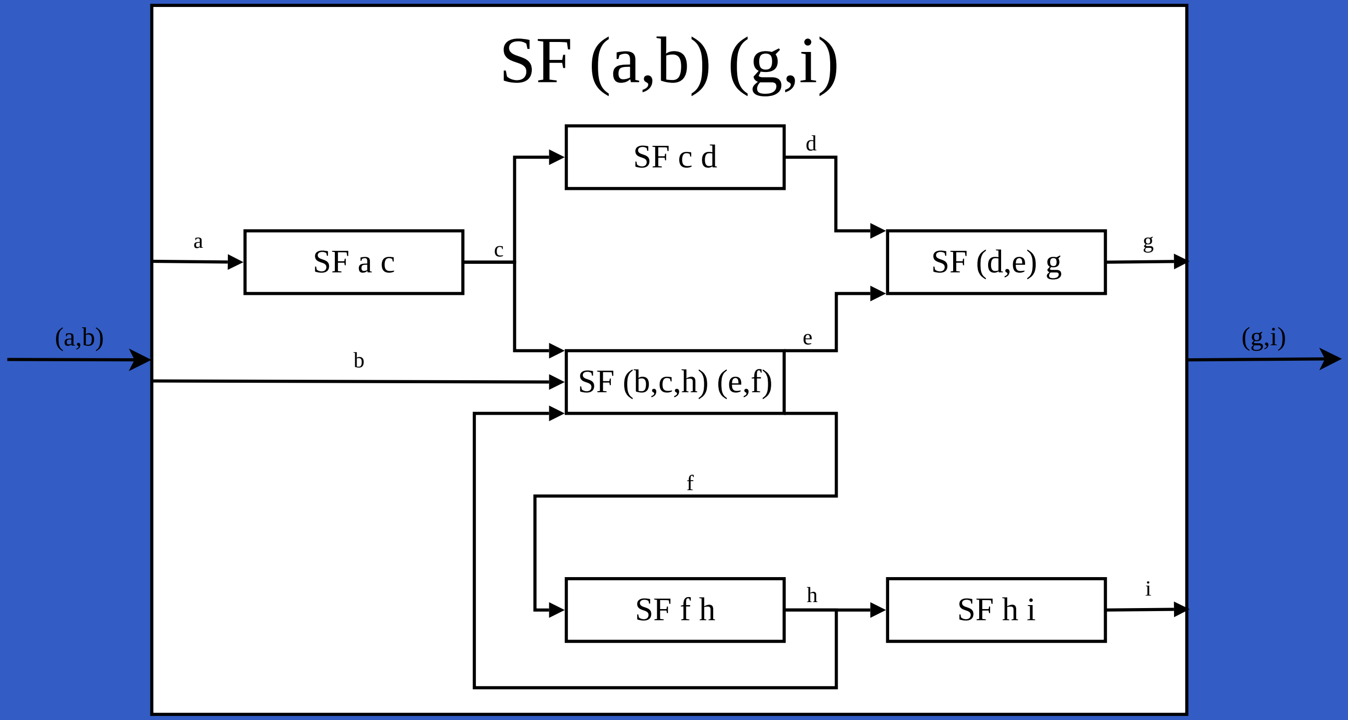
Outline

- The current Yampa implementation
- The problem, by example
- Proposed solution
- Difficulties of the solution

The current Yampa implementation

- A Yampa program can be represented as a dynamic network of signal functions.



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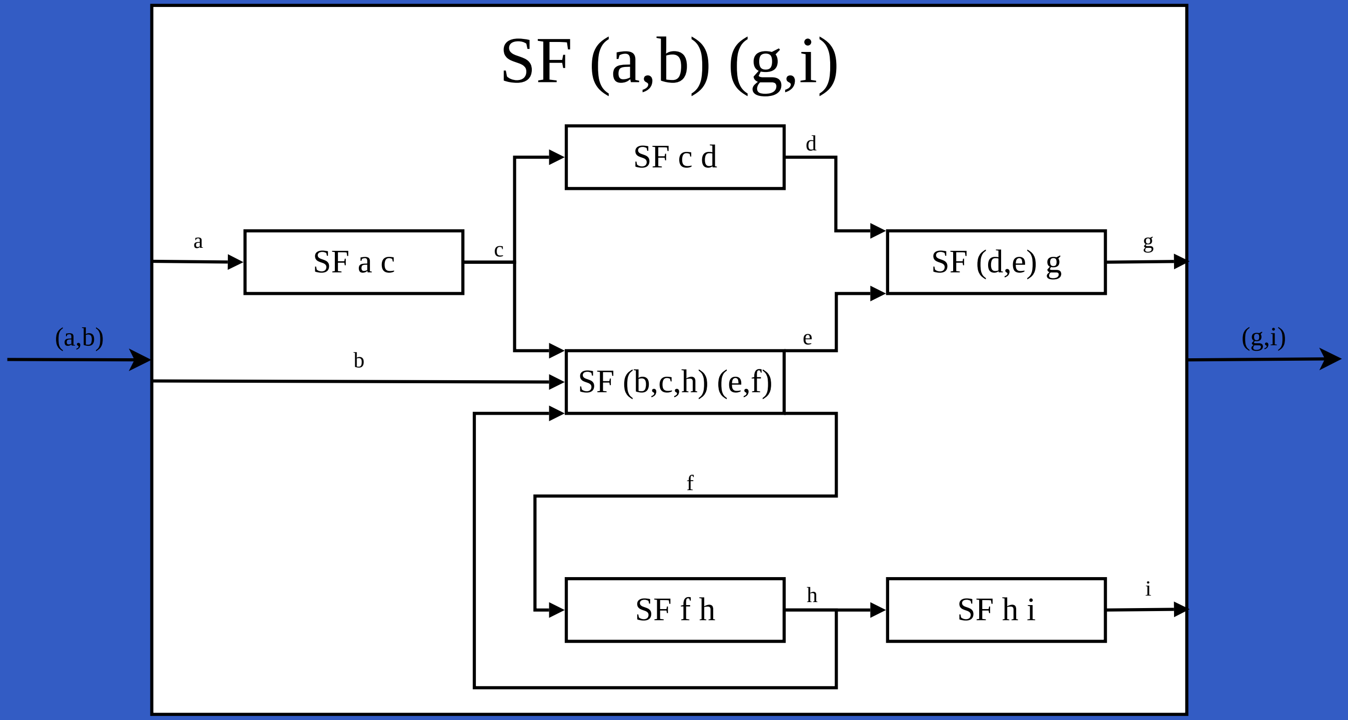

- At each time step, the value of each signal function is re-calculated.

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- Any *stateless* signal functions that have unchanged input will remain unchanged.
- The same is true of some, but not all (eg. $integral$), *stateful* signal functions.
- Re-calculating them all every time step is a waste of computational resources.

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- We can a construct graph recording:
  - Which signal functions will output a constant signal while their input remains unchanged.
  - The dependencies of each signal function.
- At each time interval, we can propagate changes through the network.
- Unfortunately, the Yampa implementation creates a lot of incidental dependencies.

The problem, by example

$$sfDisF, sfDisR, sfDisL :: SF\ Input\ Distance$$

$$sfLampCol :: SF\ Distance\ Colour$$

$$sfOut :: SF\ (Colour, Direction) \rightarrow Output$$

$$turnDir :: Distance \rightarrow Distance \rightarrow Distance \rightarrow Direction$$

$$robot :: SF\ Input\ Output$$

$$\begin{aligned}
robot = \mathbf{proc}\ inp \rightarrow \mathbf{do}& \\
&fDis \leftarrow sfDisF \prec inp \\
&lDis \leftarrow sfDisR \prec inp \\
&rDis \leftarrow sfDisL \prec inp \\
&dir \leftarrow arr\ turnDir \prec (fDis, lDis, rDis) \\
&col \leftarrow sfLampCol \prec fDis \\
&sfOut \prec (col, dir)
\end{aligned}$$

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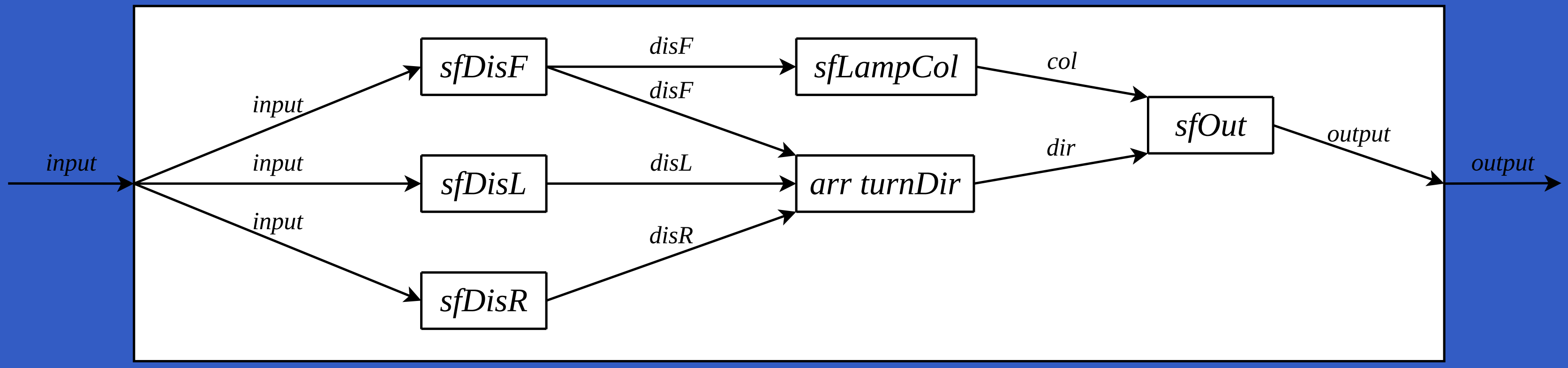
- Ideally, we'd like a dependency graph that looks like:



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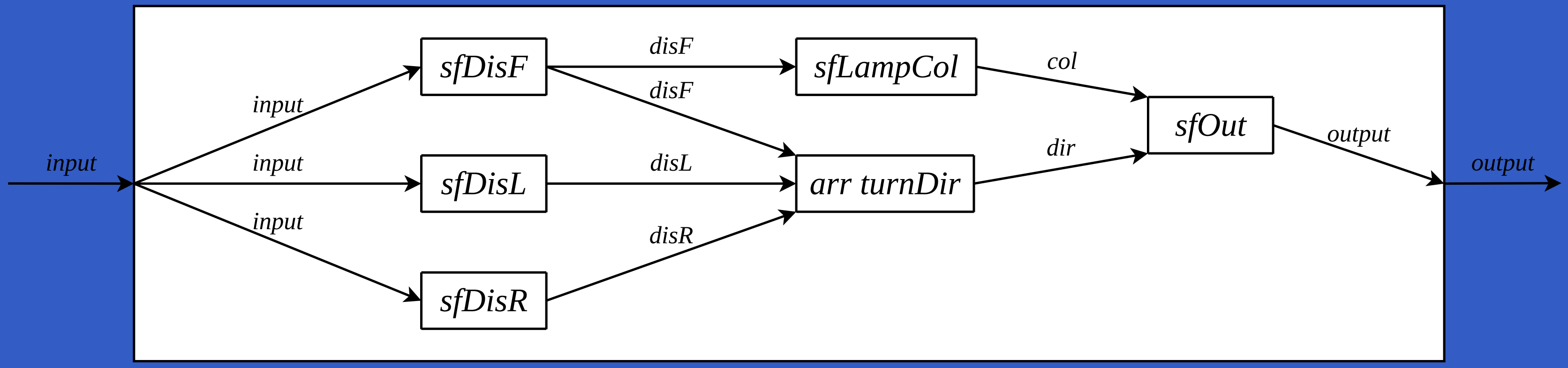

- But the code so far has been syntactic sugar.

The problem, by example

After translation into point free arrow code, it becomes:

$$
\begin{array}{lll}
\multicolumn{3}{l}{robot =} \\
\quad arr\ id \&\&\& sfDisF & & \ggg \\
\quad arr\ id \&\&\& ((\lambda(inp, fDis) \rightarrow inp) & \ggg sfDisL) & \ggg \\
\quad arr\ id \&\&\& ((\lambda((inp, fDis), lDis) \rightarrow inp) & \ggg sfDisR) & \ggg \\
\quad arr\ id \&\&\& ((\lambda(((inp, fDis), lDis), rDis) \rightarrow (fDis, lDis, rDis)) & \ggg arr\ turnDir) & \ggg \\
\quad arr\ id \&\&\& ((\lambda((((inp, fDis), lDis), rDis), dir) \rightarrow fDis) & \ggg sfLampCol) & \ggg \\
\quad arr\ (\lambda(((((inp, fDis), lDis), rDis), dir), col) \rightarrow (col, dir)) & & \ggg \\
\quad sfOut & &
\end{array}
$$

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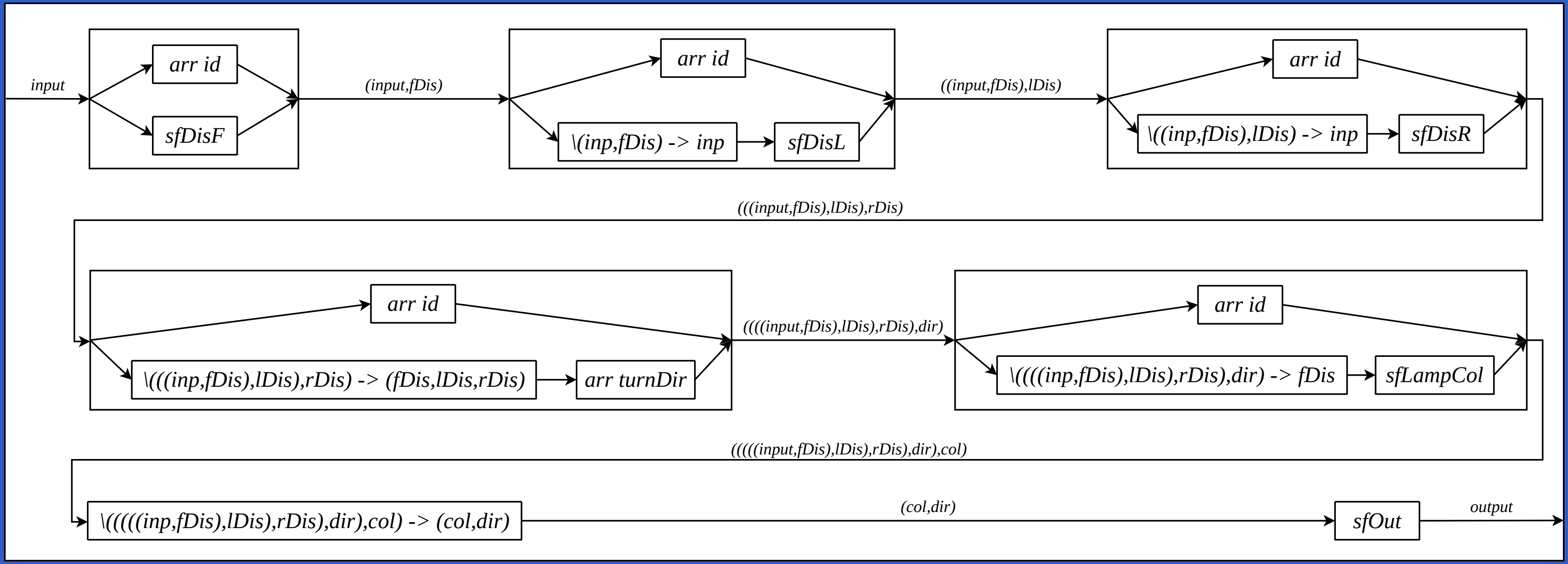

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- But try to keep the advantages of arrows, which include:
  - A syntax similar to the syntactic sugar.
  - A clean, modular semantics that supports reasoning.
- We can then create dependency graphs without incidental dependencies.

Difficulties of the solution

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  - Dependencies will change as the network structure changes.
  - Signal functions are first class entities, and thus can be created during runtime.
- How do you incorporate feedback into a dependency graph?

Summary

- The current Yampa implementation is not as efficient as it could be.
- This is due to the restrictions of the Arrow Framework.
- A new implementation is needed, but it should keep the strengths of Arrows.