**1. (One View of) Programmable Inference: the Goal and the Challenge**

**The Goal: Automate Inference Algorithms from Declarative Specs**
- **Target Distribution**
- **Proposal**
- **Importance Sampler**
- **Transition Proposal**
- **Generative Family**
- **Variational Family**

**The Challenge: Densities**
- Simple enough if each program supports:
  - Simulation
  - Density Evaluation
- But densities can:
  - Be intractable
  - Fail to exist (with respect to the usual reference measures)

**Existing Approaches to Density in Probabilistic Programming**
- **Trace-Based** (Gen, Pyro, ProbTorch, WebPPL)
  - Compute joint densities of traces of all primitive random choices made by prob. progs — easy multiplications
  - Proposal/variational family primitive choices must be in 1-1 correspondence with target distribution choices
  - Expressiveness rests on which primitives are available
- **Symbolic** (Hakaru, Stochastic, PSI, Blite et al; Mettman & Org)
  - Transform prob. progs into (unbiased estimators of) densities with respect to certain reference measures
  - Must “total” (exactly evaluate) possibly intractable densities that appear in denominators (e.g., proposals)
  - Supports some loops, but not general recursion

**2. Our Approach: Inference Towers**

- We do not require densities, but do require programs to be equipped with **internal proposals**

**Why?** Given any two valid tower-equipped programs over the same output space (F and G, with F << G), we’ll show how to automatically derive a valid importance sampler.

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**3. Automatic Differentiation for Density Ratios of Tower-Equipped Probabilistic Programs**

**Given two probabilistic programs, F and G, their inference towers define a bijection between all rand() calls made by F* and G*, which are marginally equal to F and G:**

*F* → *G*

**4. Beyond Importance Sampling: SMC, MCMC, and Variational Inference**

**Possible to develop versions of SMC, MCMC, and SVI that use these towers, enabling expressive proposals and variational families.**

**Right:** variational inference with a variational family that itself calls a recursive importance resampling procedure.