EcoRNN: Efficient Computing of LSTM RNN on GPUs

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EcoSystem

Background: Sequence Learning

Machine Translation

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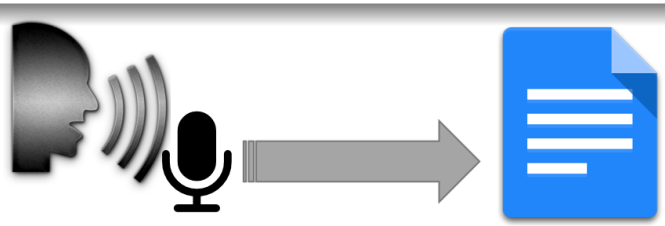
Machine Translation

Speech Recognition



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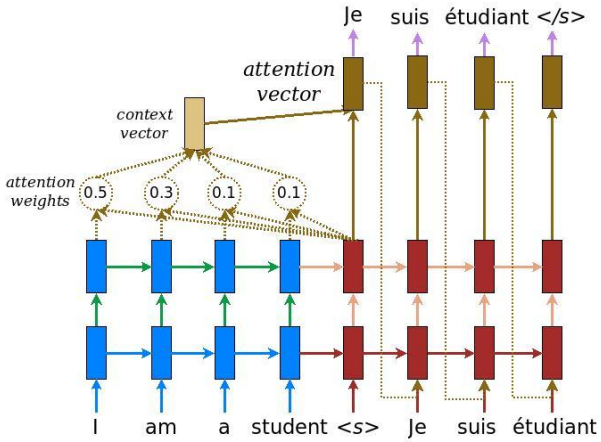

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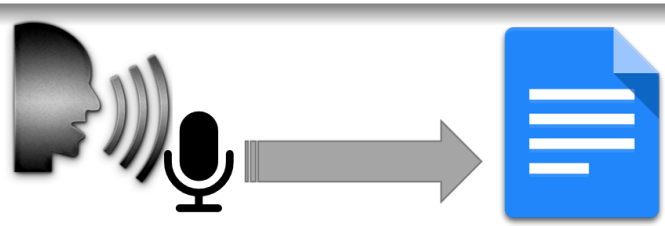
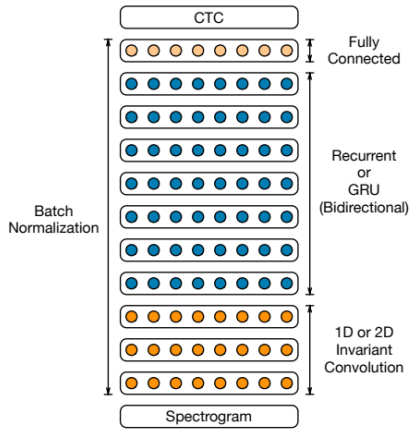
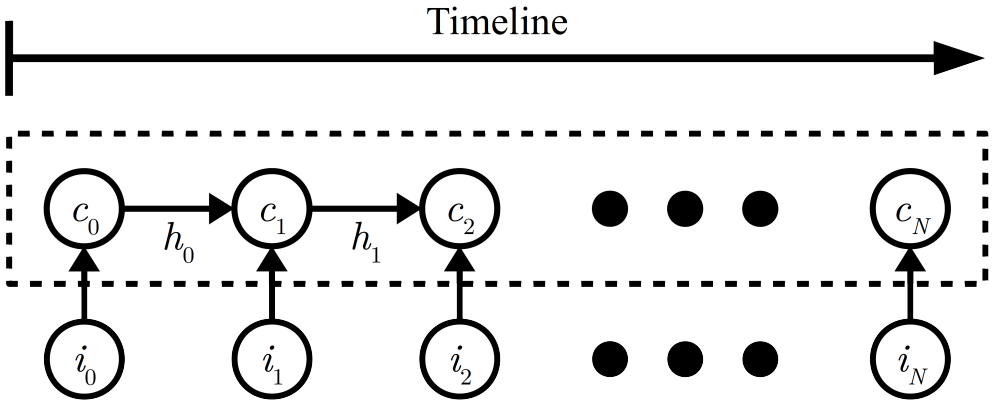




Background.Long-Short-Term-Memory (LSTM) Recurrent-Neural-Network (RNN)



c_t RNN Cell at time t i_t Cell Input h_t Cell Hidden State

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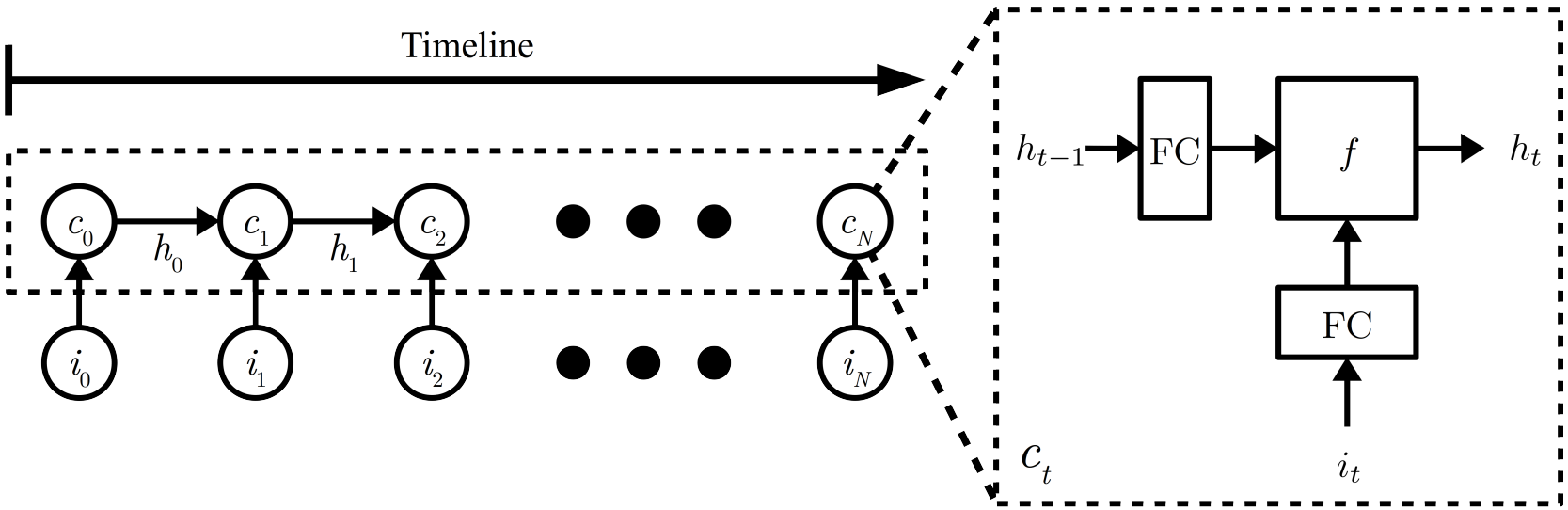

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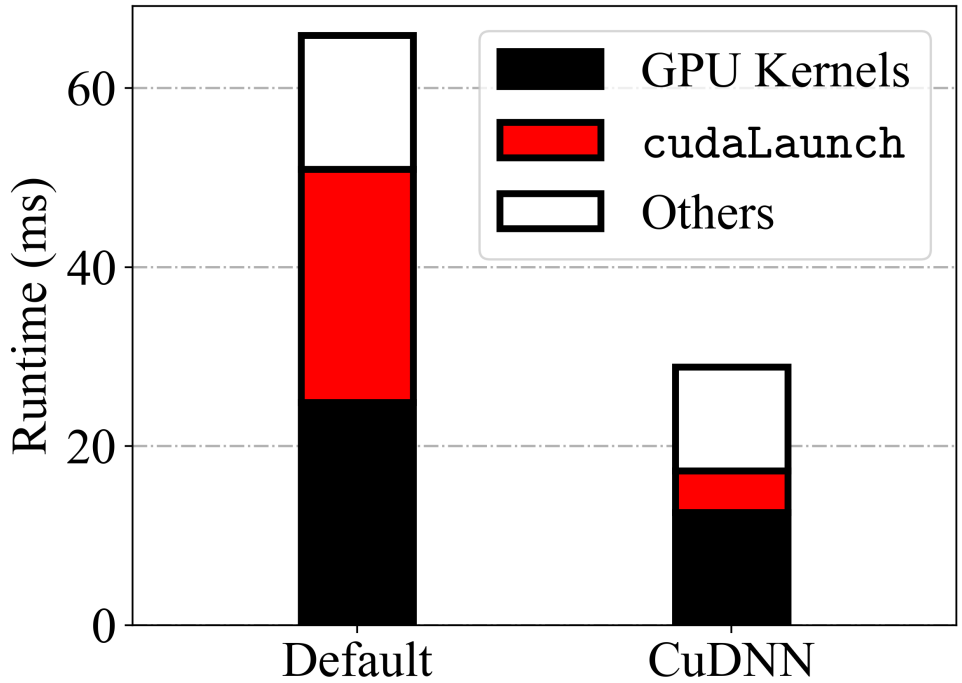
FC Fully-Connected Layer f Nonlinear Block

Problem Statement: (1) Performance

✖ ***Default*** has `cudaLaunch` **overhead**.
✖ ***CuDNN*** is **closed-source**, **limits innovation**.

Reference: *cuDNN* LSTM RNN. Appleyard et al.



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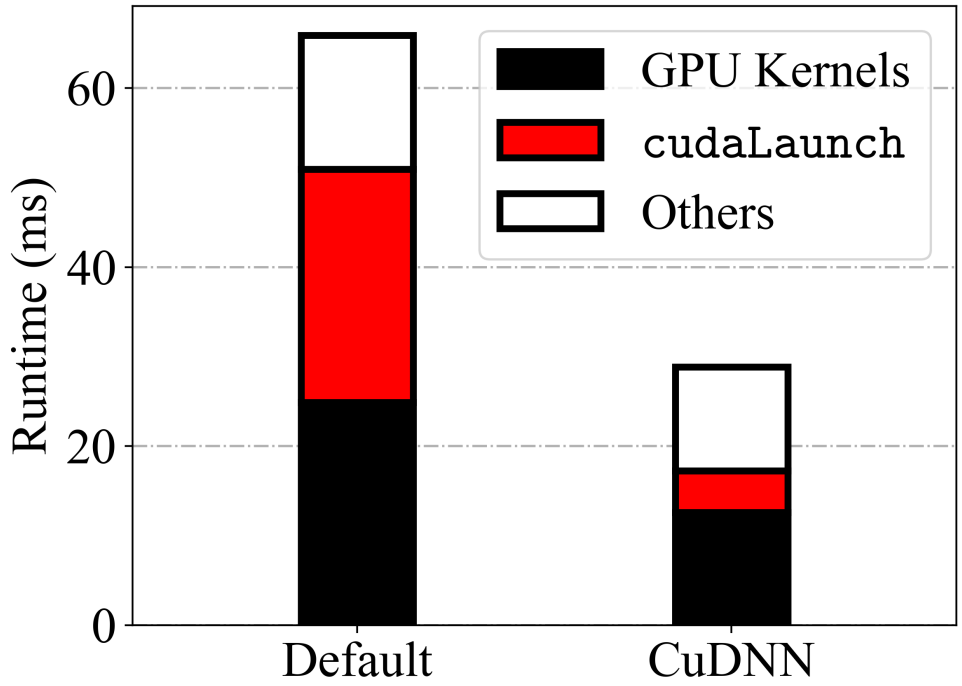
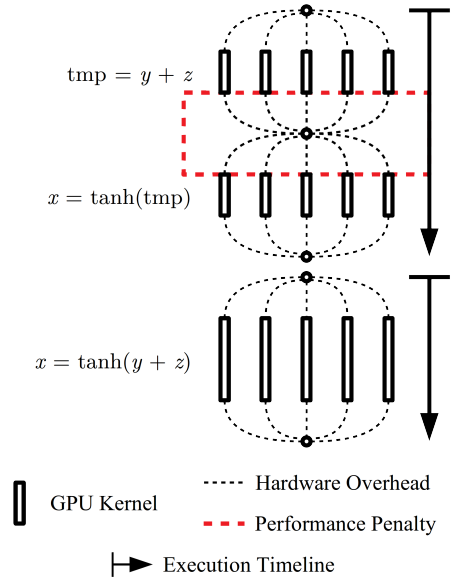
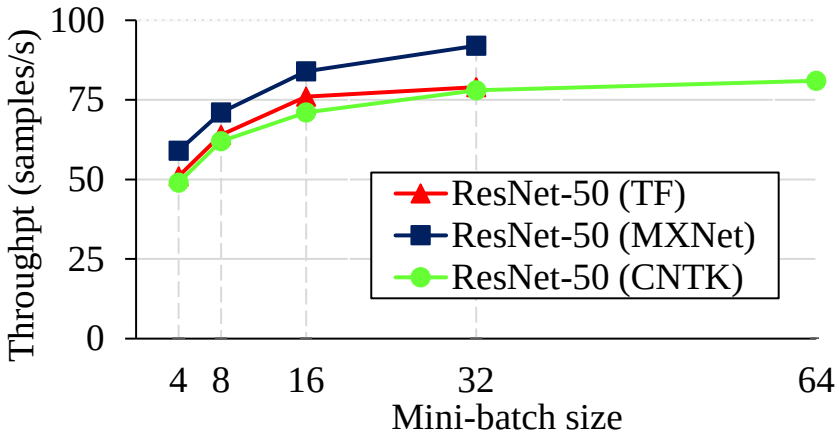
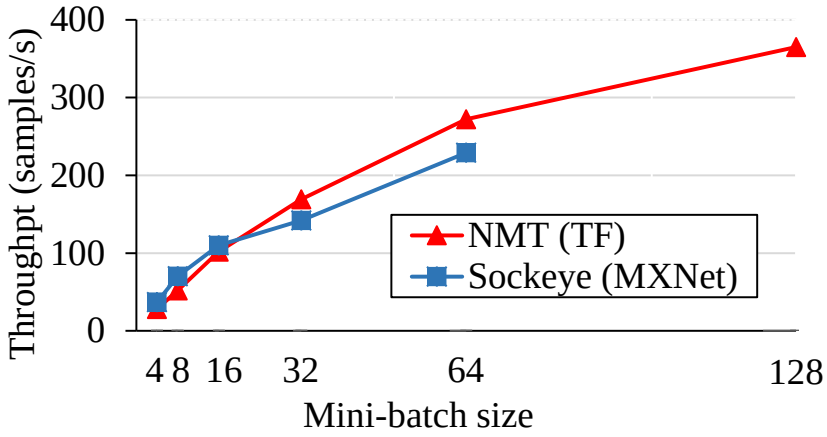




Kernel Fusion

Problem Statement: (2) Memory Capacity

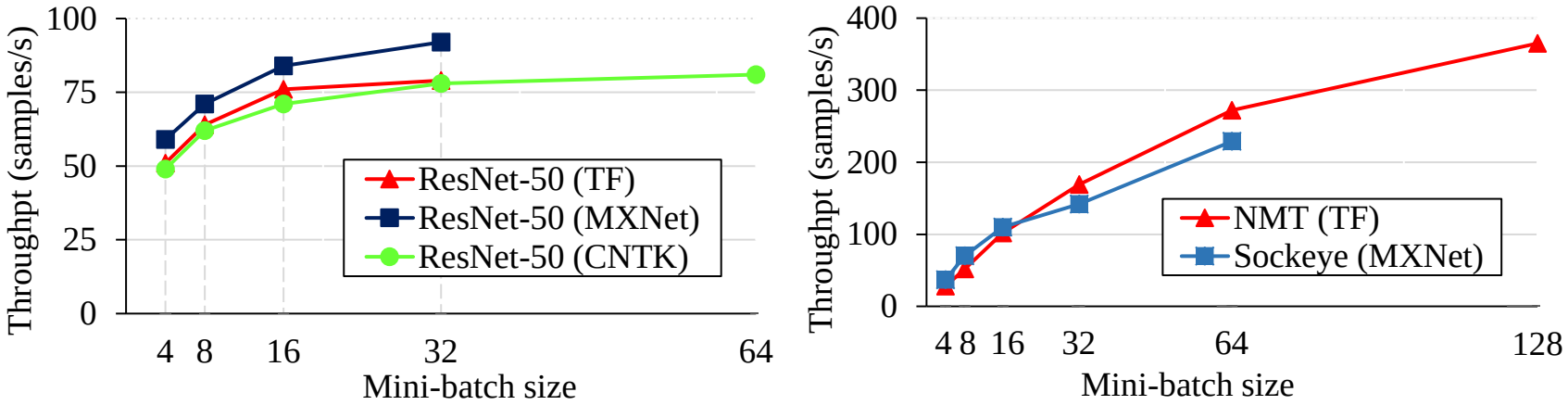




Reference: *TBD*: DNN Training Benchmark Suite. Zhu et al.

Training throughput in ResNet-50 **saturates** at large batch size.

Problem Statement: (2) Memory Capacity



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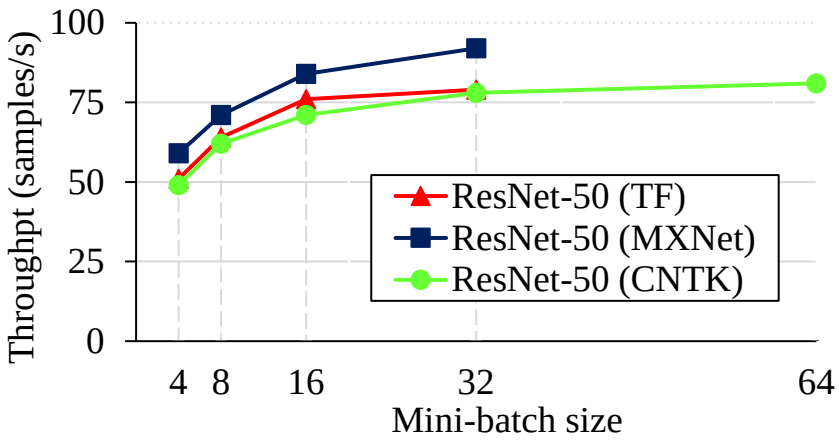
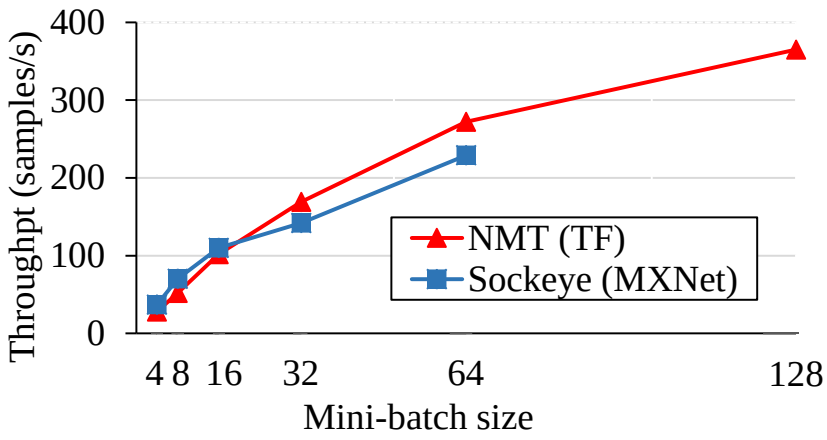
Training throughput in machine translation model increases **almost linearly**.

Problem Statement: (2) Memory Capacity





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✖ RNN training is **Memory Capacity**-bounded.

EcoRNN Full Vision

EcoRNN is a new **open-source** implementation that has performance **comparable with or even better than *CuDNN***. It has **smaller memory footprint** and supports **auto-tuning**.

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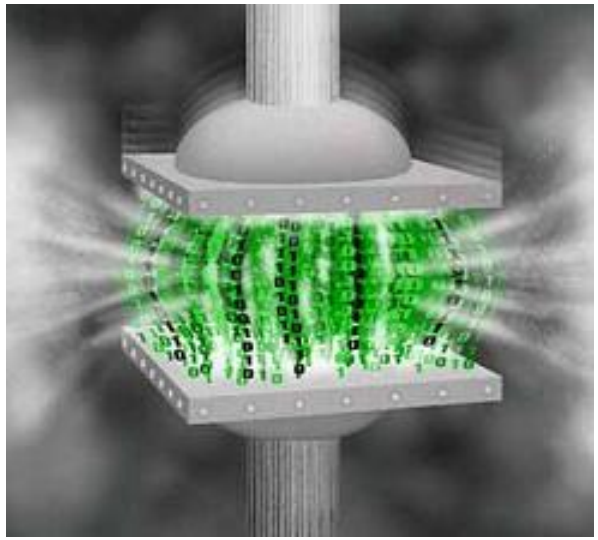

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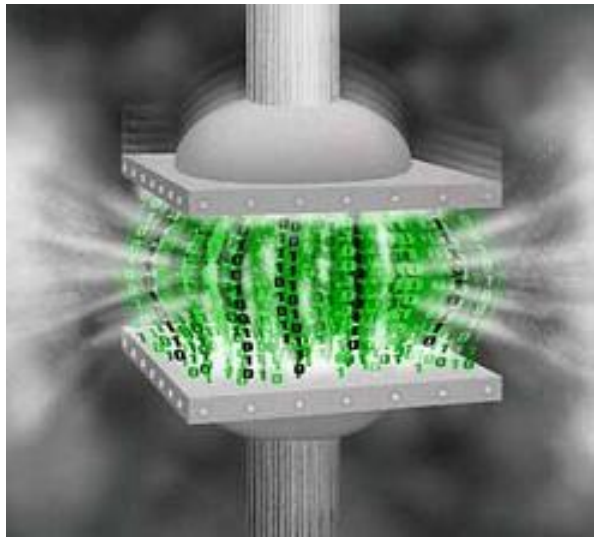
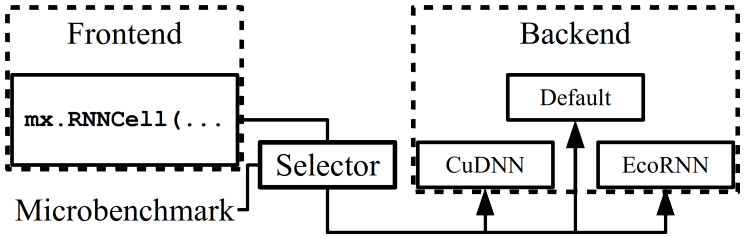
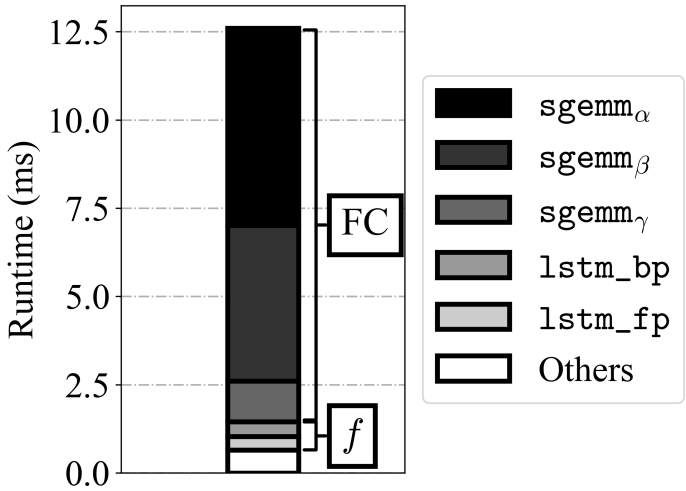
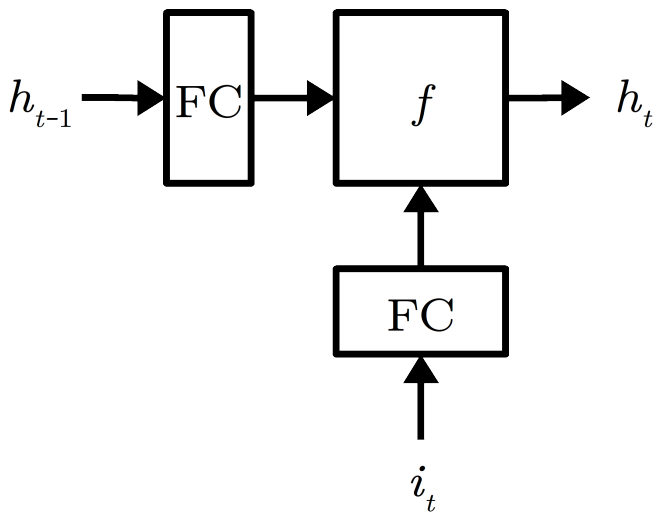




All changes are **transparent** to the programmers.

Preliminary Results: (1) Performance





The runtime bottleneck is **FC layers**.

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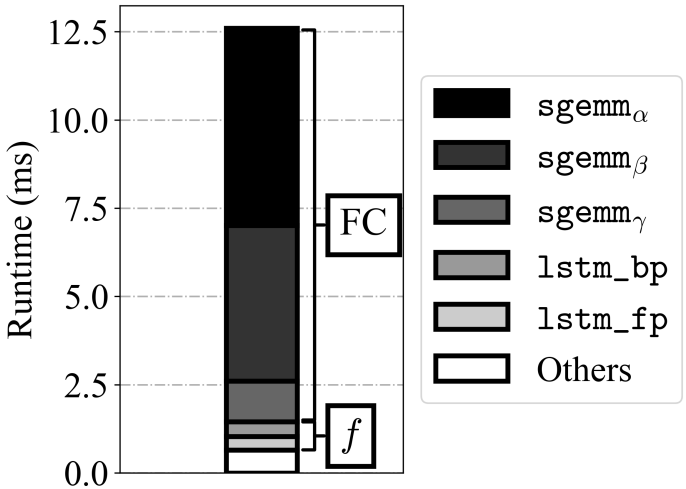
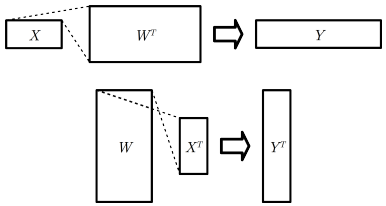
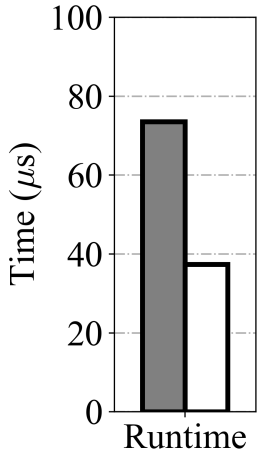
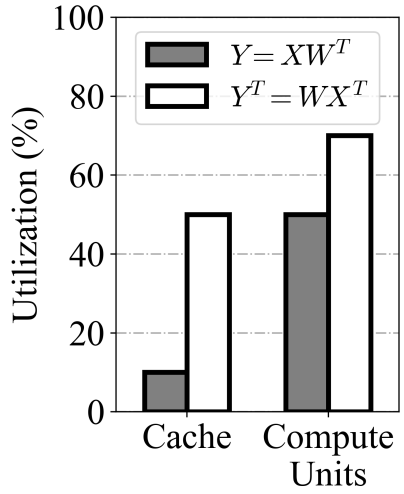


Data Layout Optmization







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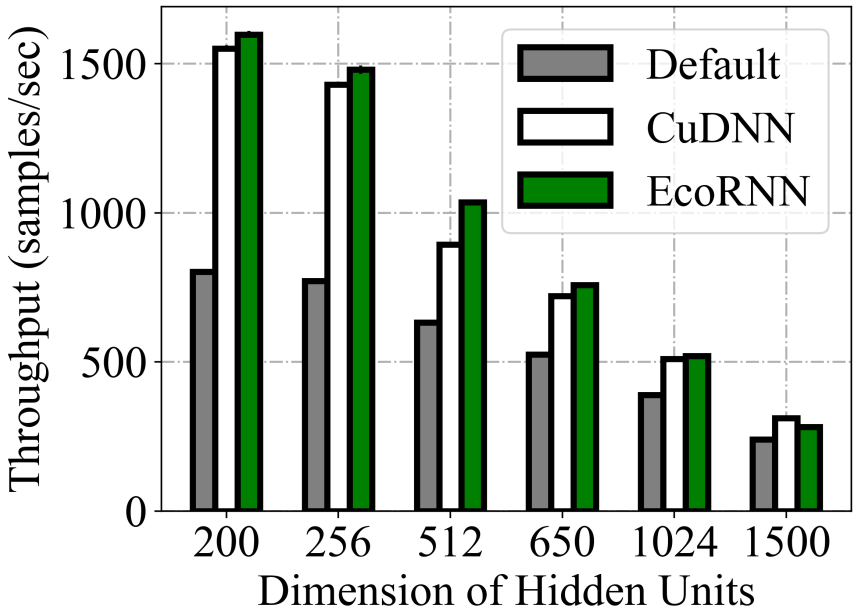
$\Rightarrow$

Data layout optimization **improves cache hit rate**.

Preliminary Results: (1) Performance

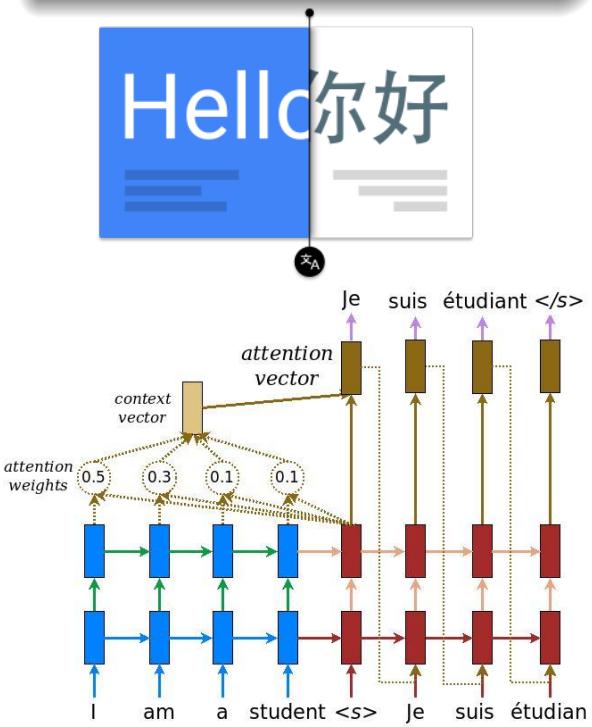
Training Throughput Comparison on the MXNet Language Modeling Benchmark



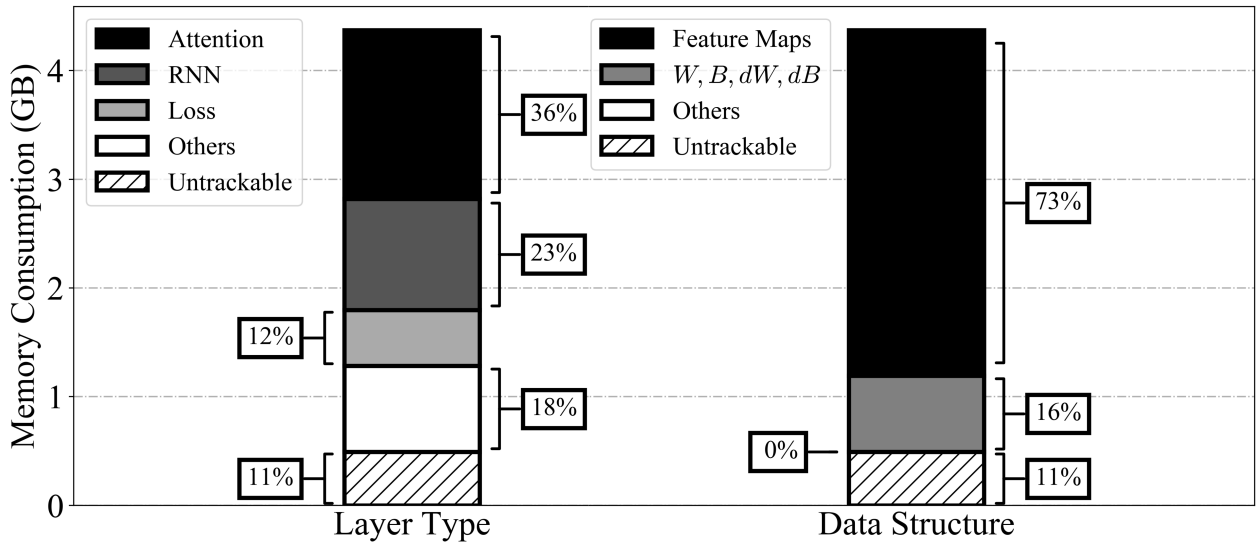
✓ Up to 2 × faster than ***Default***, and
✓ Up to 1.3× faster than ***CuDNN***.

Preliminary Results: (2) Memory Capacity

Machine Translation



Memory Consumption Profile of the Machine Translation Model



The memory bottleneck is **Features Maps of Attention and RNN Layers**.

Future Work

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  - Same observation made by ***Baidu Persistent RNN***.
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- Memory Compression $\Leftarrow$ ***Gist*** (Jain et al., ISCA'18)

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- **Problem Statement**
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- **Future Work**
  - Weight Parameter Reuse ⇐ **Machine Learning Compilers**
  - The memory bottleneck in machine translation model is **Feature Maps of Attention and RNN Layers** ⇐ ***Gist***.

Backup Slide

- Experimental Settings
  - *CUDA* Toolkit 8, *cuDNN* 6, *MXNet* Ver. 0.11.0.
- *DeepSpeech2* Training Throughput