Function-as-a-Service Application Service Composition: Implications for a Natural Language Processing Application

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Outline

- Background
- Research Questions
- Experimental Implementation
- Experiments/Evaluation
- Conclusions

Natural Language Processing

How can computers be used to understand speech?

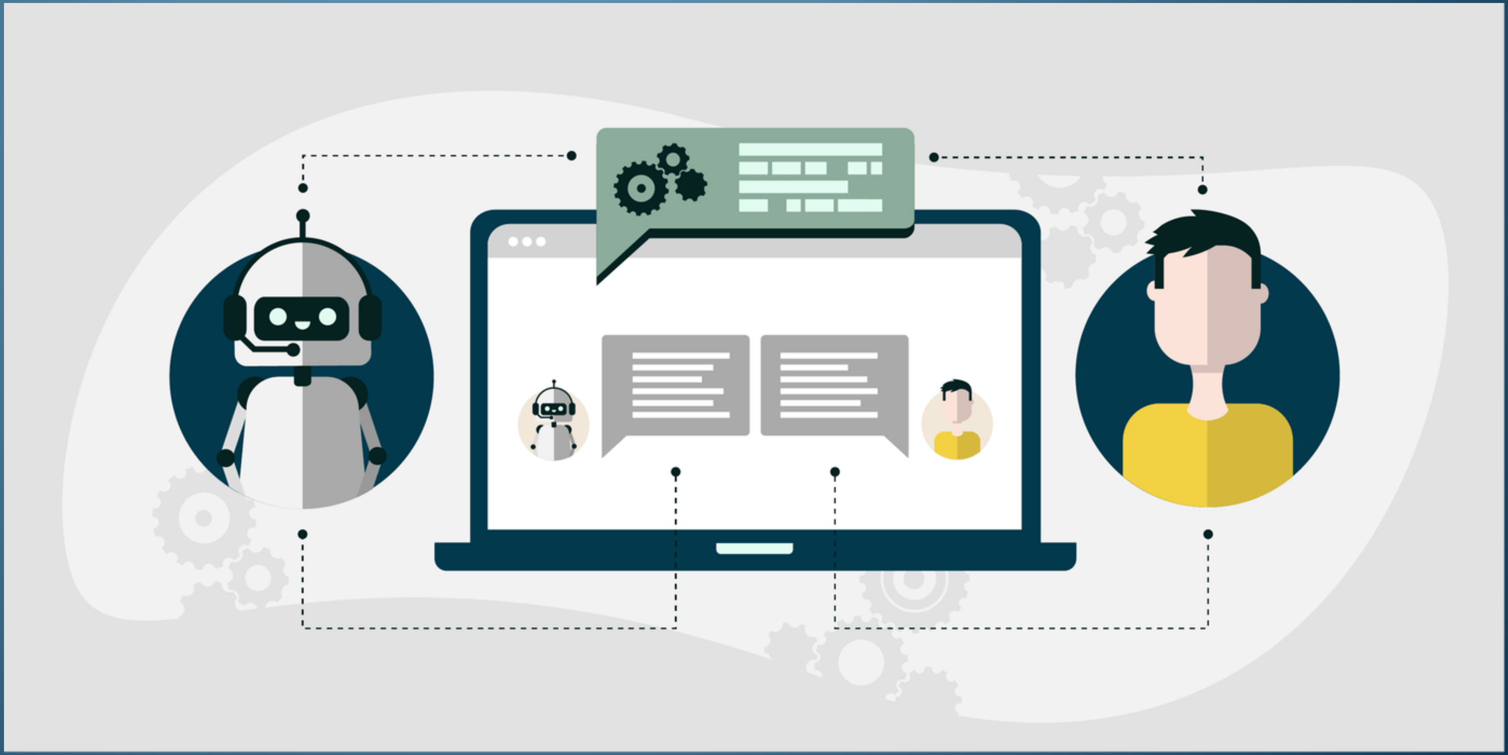


Image from: https://aliz.ai/natural-language-processing-a-short-introduction-to-get-you-started//

NLP Dialogue modeling components

- Intent Tracking
  - Determines what the user wants
- Policy Management
  - Choose the agent action
- Text Generation
  - Generate the actual text

NLP Dialogue modeling components

- Considering a scenario where a user asks : "What is Milad's phone number ?"
  - Intent tracker -> Question
  - Policy Management -> To answer
  - Text generator -> "The number is 123-456-7890"
- These phases include an initialization and inference step

Serverless Computing

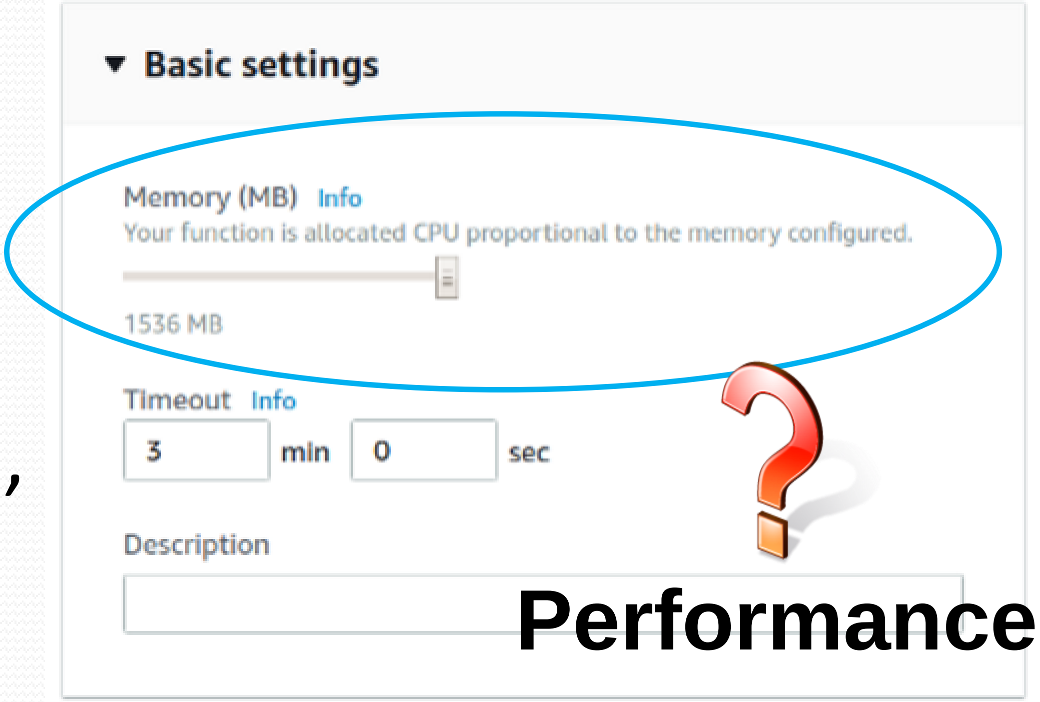
Image from: https://mobisoftinfotech.com/resources/blog/serverless-computing-deploy-applications-without-fiddling-with-servers/

Serverless Computing

- Function-as-a-Service (FaaS) platforms
  - New cloud computing delivery model that provides a compelling approach for hosting applications
  - Bring us closer to the idea of instantaneous scalability
- Our goals- research implications of:
  - Memory reservation
  - Service composition
  - Adjustment of neural network weights
  - In the context of NLP application deployment

Memory Reservation

- Lambda memory reserved for functions
- UI provides "slider bar" to set function's memory allocation
- Resource capacity (CPU, disk, network) coupled to slider bar: *"every **doubling** of memory, **doubles** CPU…"*



▾ Basic settings

Memory (MB) Info
Your function is allocated CPU proportional to the memory configured.
1536 MB

Timeout Info
3 min 0 sec

Description

Performance

- **How does memory allocation affect performance?**

Infrastructure Freeze/Thaw Cycle

Performance

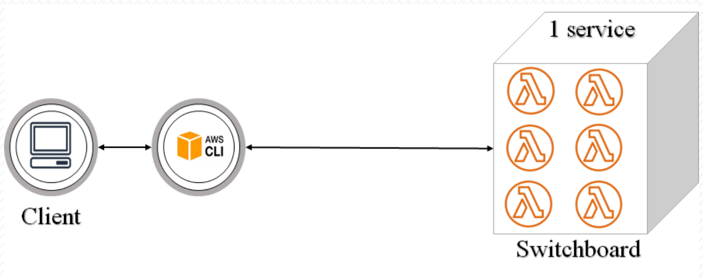
- Unused infrastructure is deprecated
  - ***But after how long?***
- AWS Lambda: Bare-metal hosts, firecracker micro-VMs
- Three infrastructure states:
- **Fully COLD (Cloud Provider/Host)**
  - Function package transferred to hosts
- **Runtime environment COLD**
  - Function package cached on Host
  - No function instance or micro-VM
- **WARM (firecracker micro-VM)**
  - Function instances/micro-VMs ready

Image from: Denver7 – The Denver Channel News

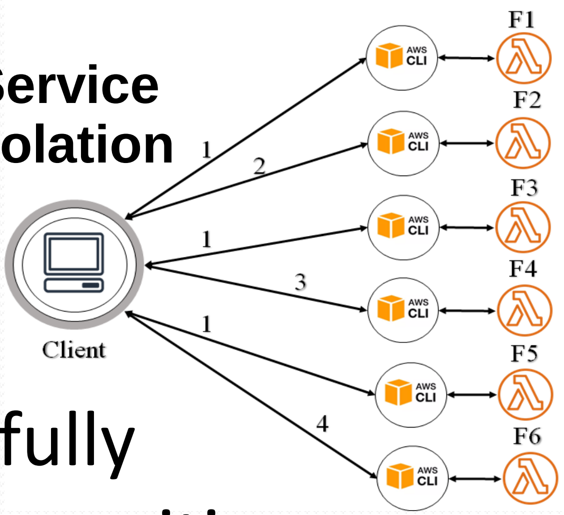
Service Composition

- **How should applications be composed for deployment to serverless computing platforms?**

Switchboard / Asynchronous



Service isolation



- Fully aggregated (Switchboard) and fully disaggregated (Service isolation) composition
- Platform limits: code + libraries ~250MB
- **How does service composition affect freeze/thaw cycle and impact performance?**

Performance

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Research Questions

RQ1: **MEMORY:** How does the FaaS function memory reservation size impact application performance?

RQ2: **COMPOSITION:** How does service composition of microservices impact the application performance?

Research Questions - 2

RQ3: **NN-WEIGHTS:** How does varying the neural network weights impact the performance of the NLP application?

RQ4: **FREEZ THAW LIFE CYCLE:** How does the service composition of our NLP application impact the freeze-thaw life cycle?

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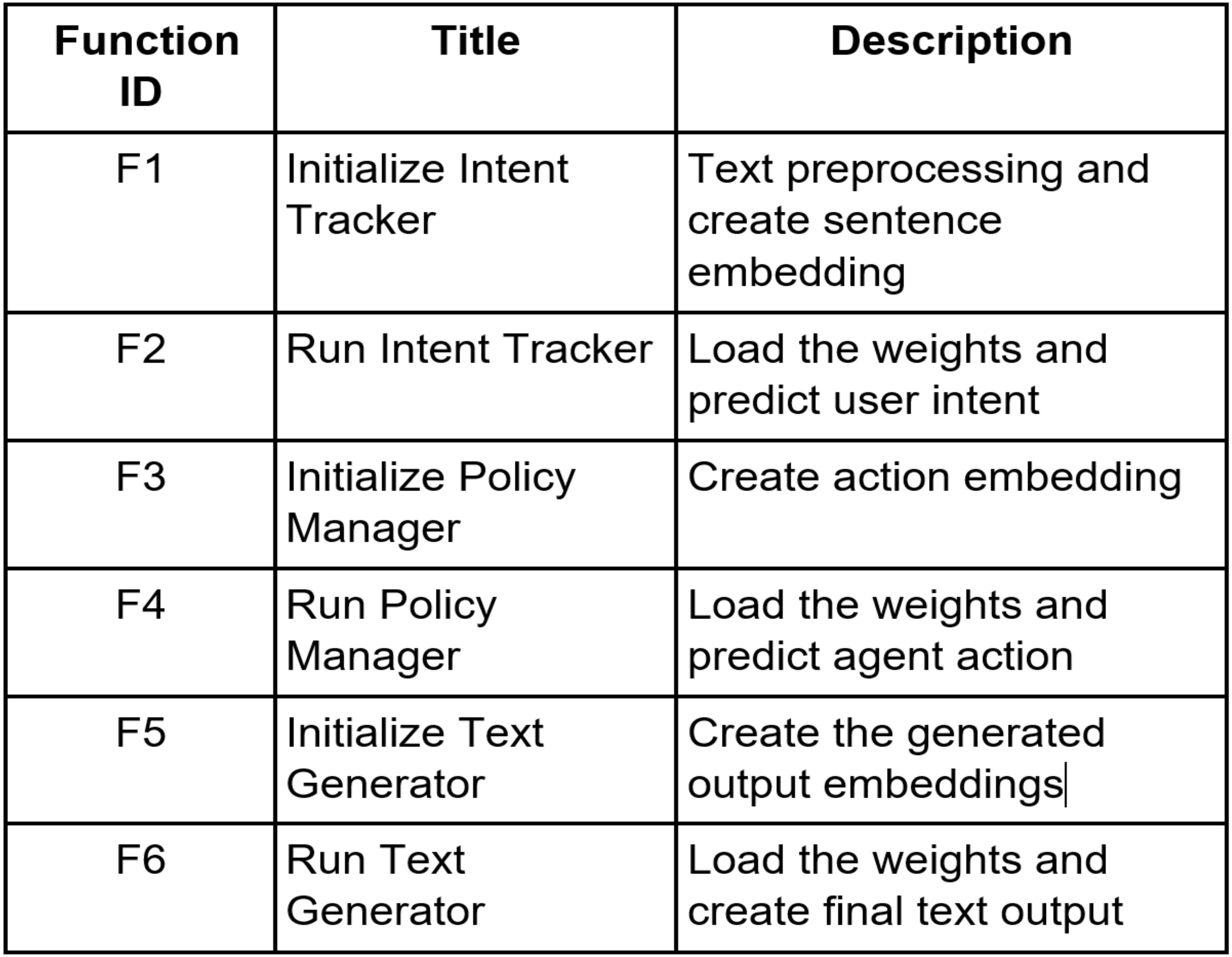
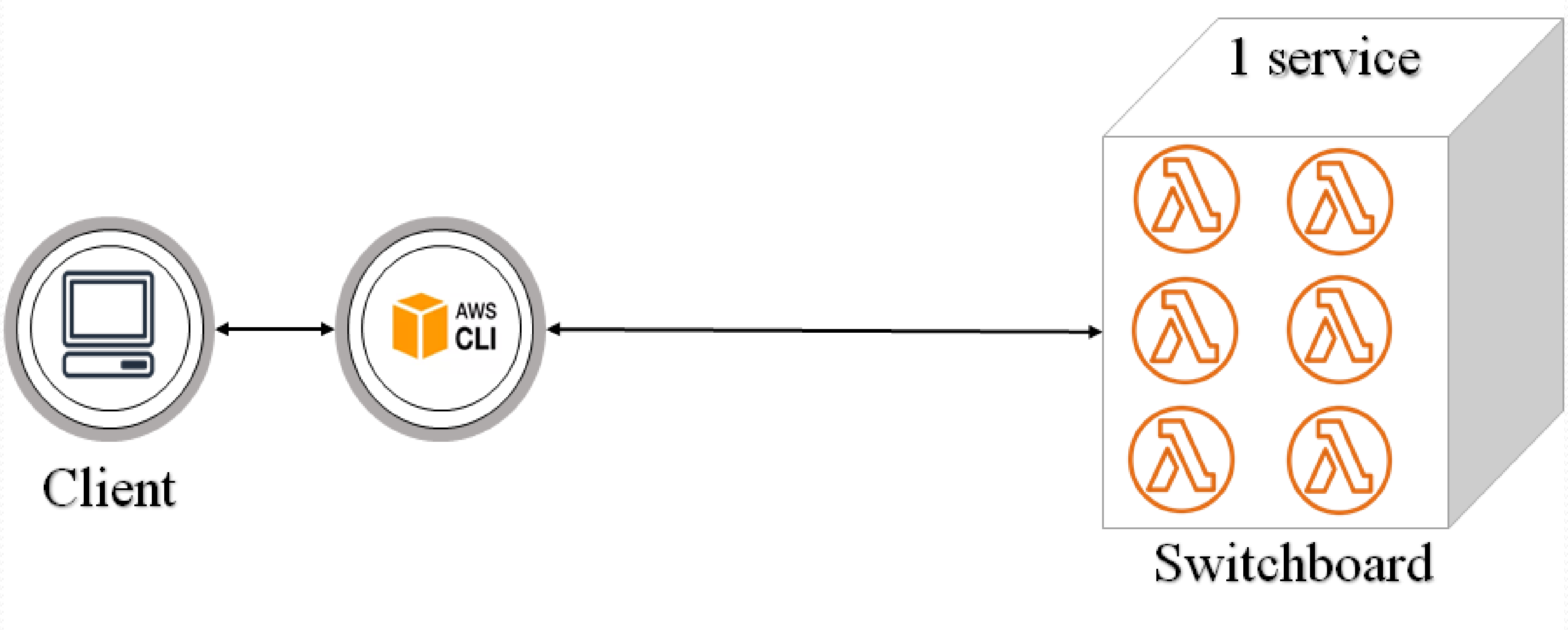
Aws lambda Inference functions



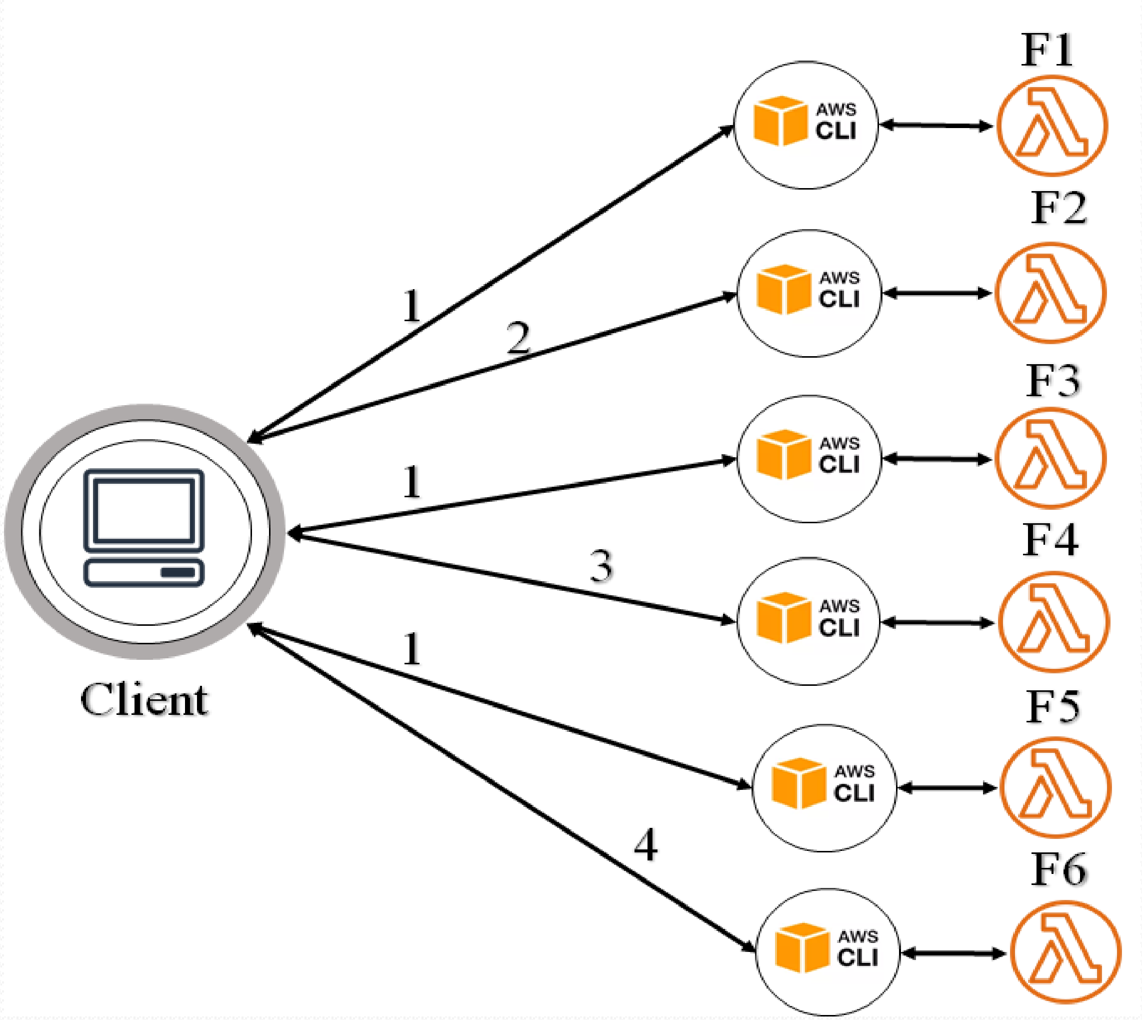
Function ID	Title	Description
F1	Initialize Intent Tracker	Text preprocessing and create sentence embedding
F2	Run Intent Tracker	Load the weights and predict user intent
F3	Initialize Policy Manager	Create action embedding
F4	Run Policy Manager	Load the weights and predict agent action
F5	Initialize Text Generator	Create the generated output embeddings
F6	Run Text Generator	Load the weights and create final text output

Switchboard architecture

- Aggregated all 6 microservices in one package
- Client initiates pipeline
- Switchboard routine accepts calls and routes internally



Full service isolation architecture



- Fully decomposed functions as independent microservices
- Cloud provider provisions separate runtime containers

Application Implementation

- Disseminate neural network models with AWS S3
- AWS CLI based client for submitting requests
- Leveraged AWS EC2’s Python Cloud9 IDE to identify and compose dependencies
- Packaged dependencies as ZIP for inclusion in Lambda FaaS function deployment
- Conformed to package size limitations (<250MB)

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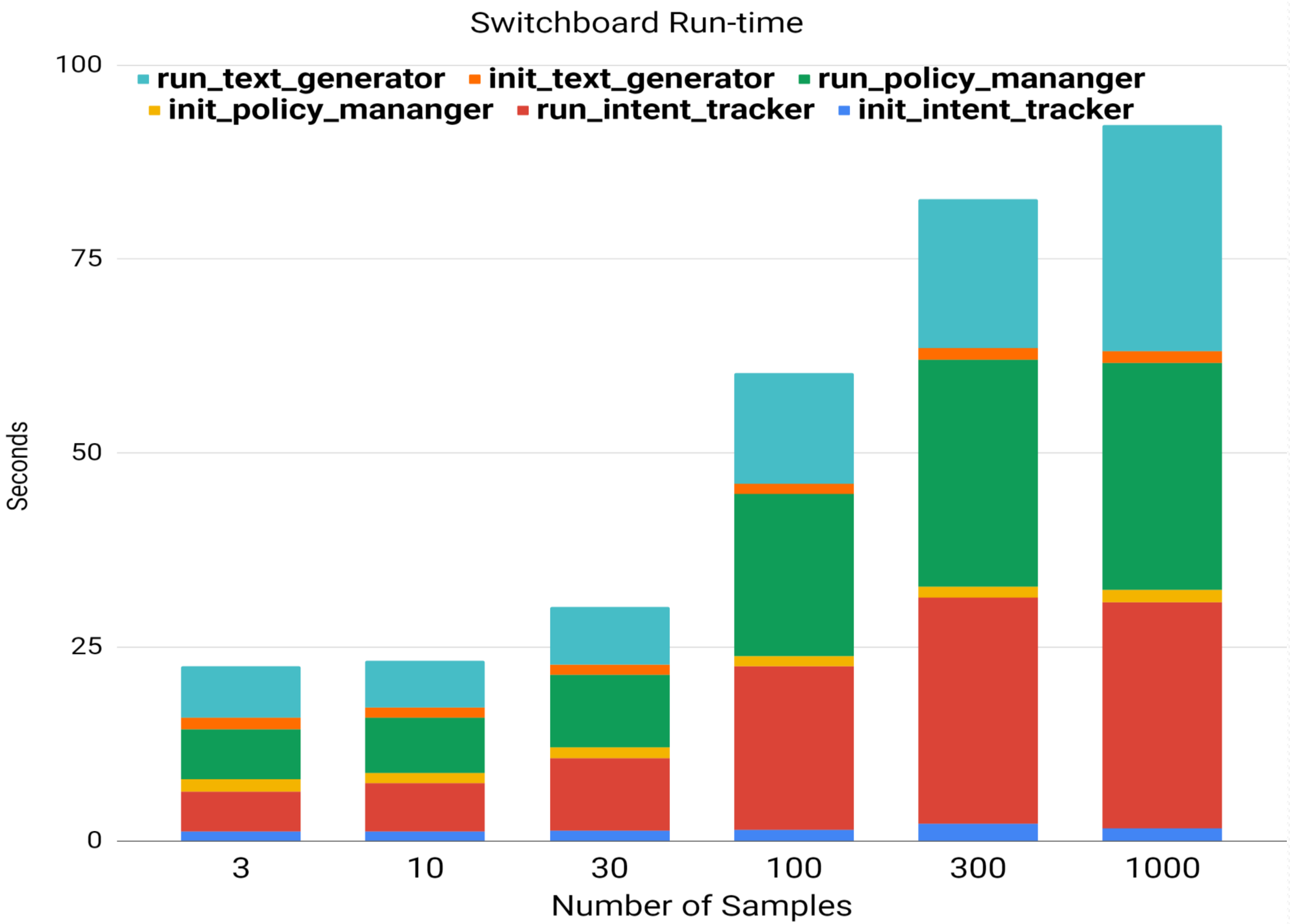
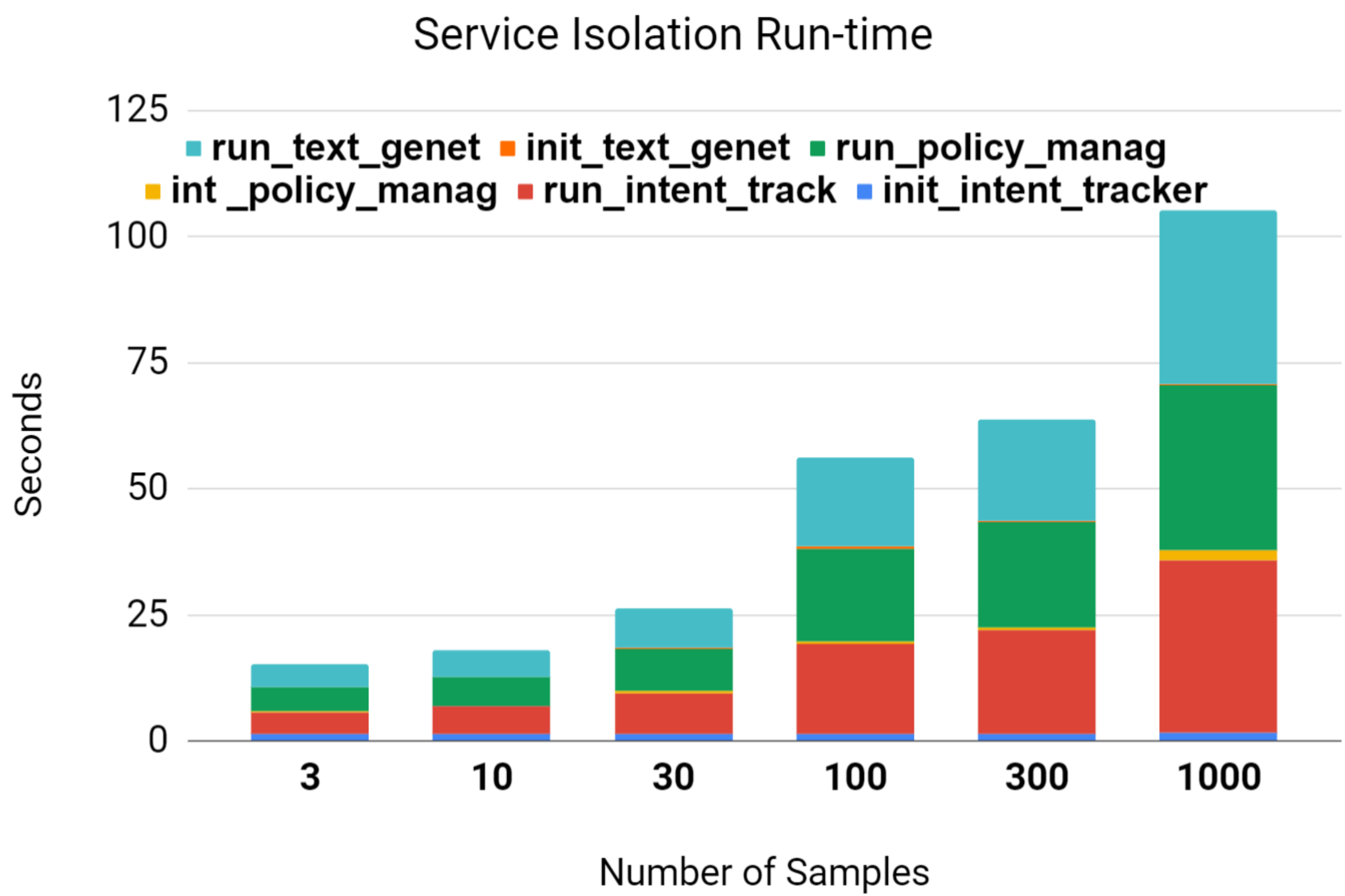
NN-Weights

How does varying the neural network weights impact the performance of the NLP application?

Runtime performance Switchboard



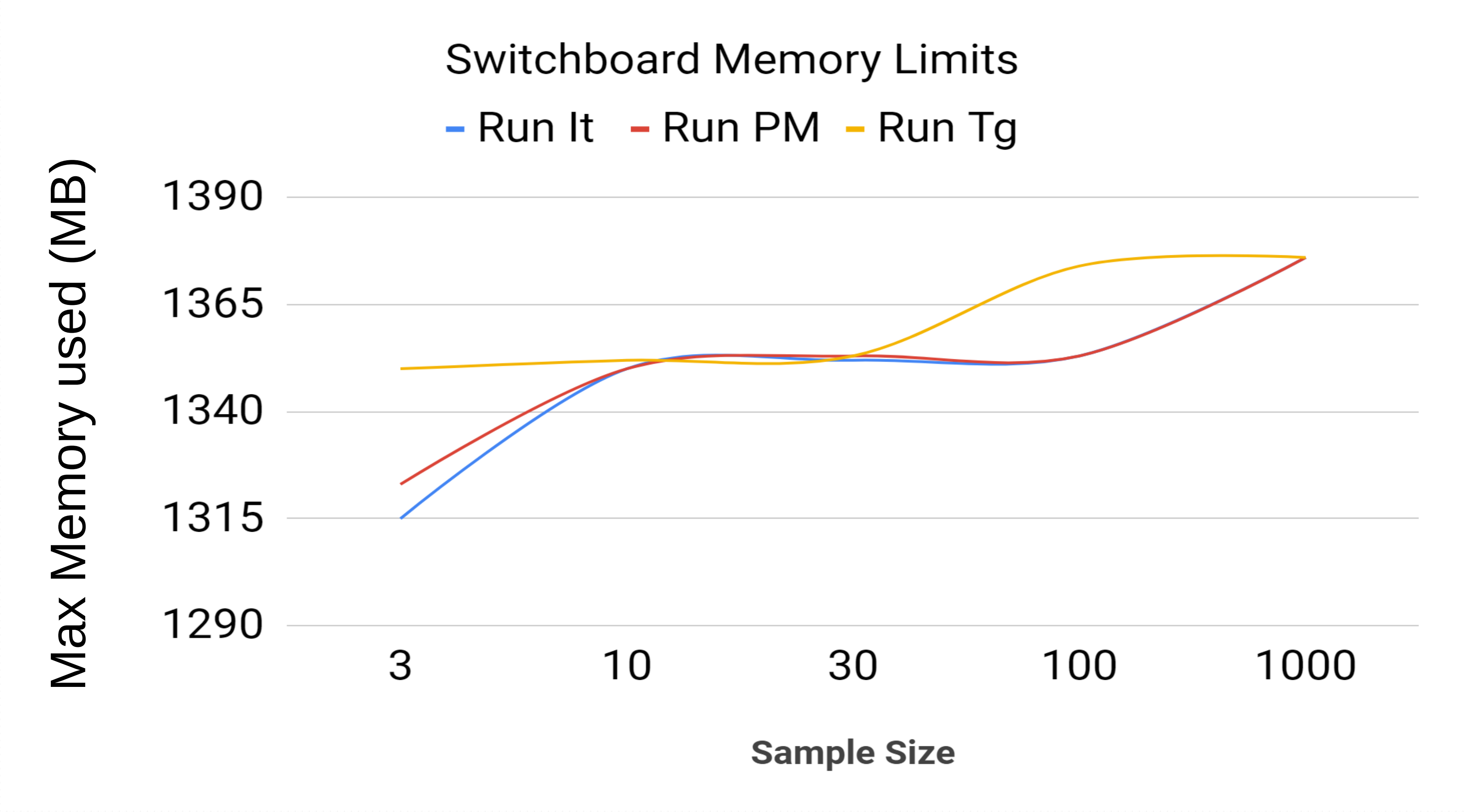
Runtime performance
Service Isolation



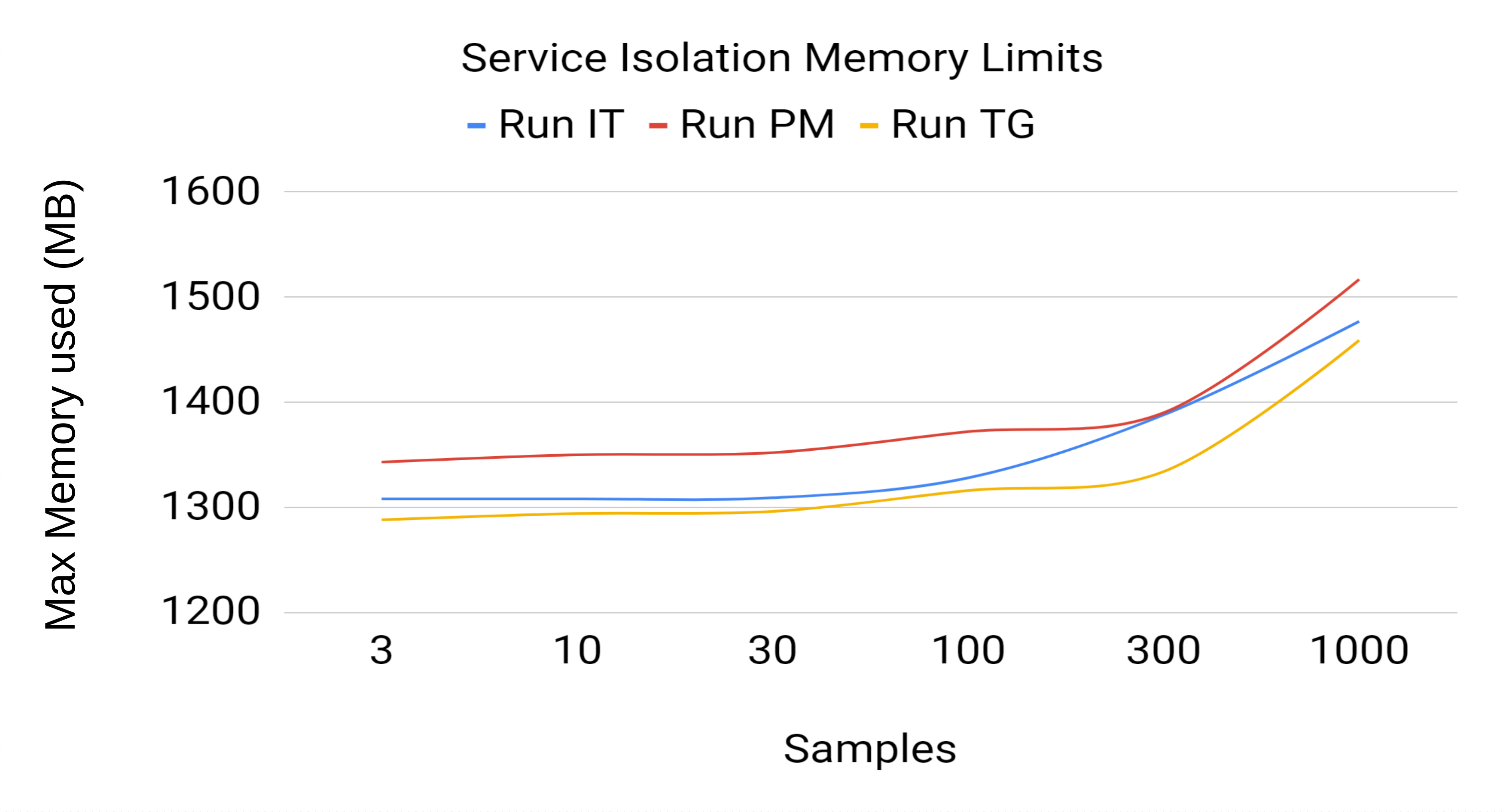
Memory

How does the FaaS function memory reservation size impact application performance?

Memory Utilization Switchboard



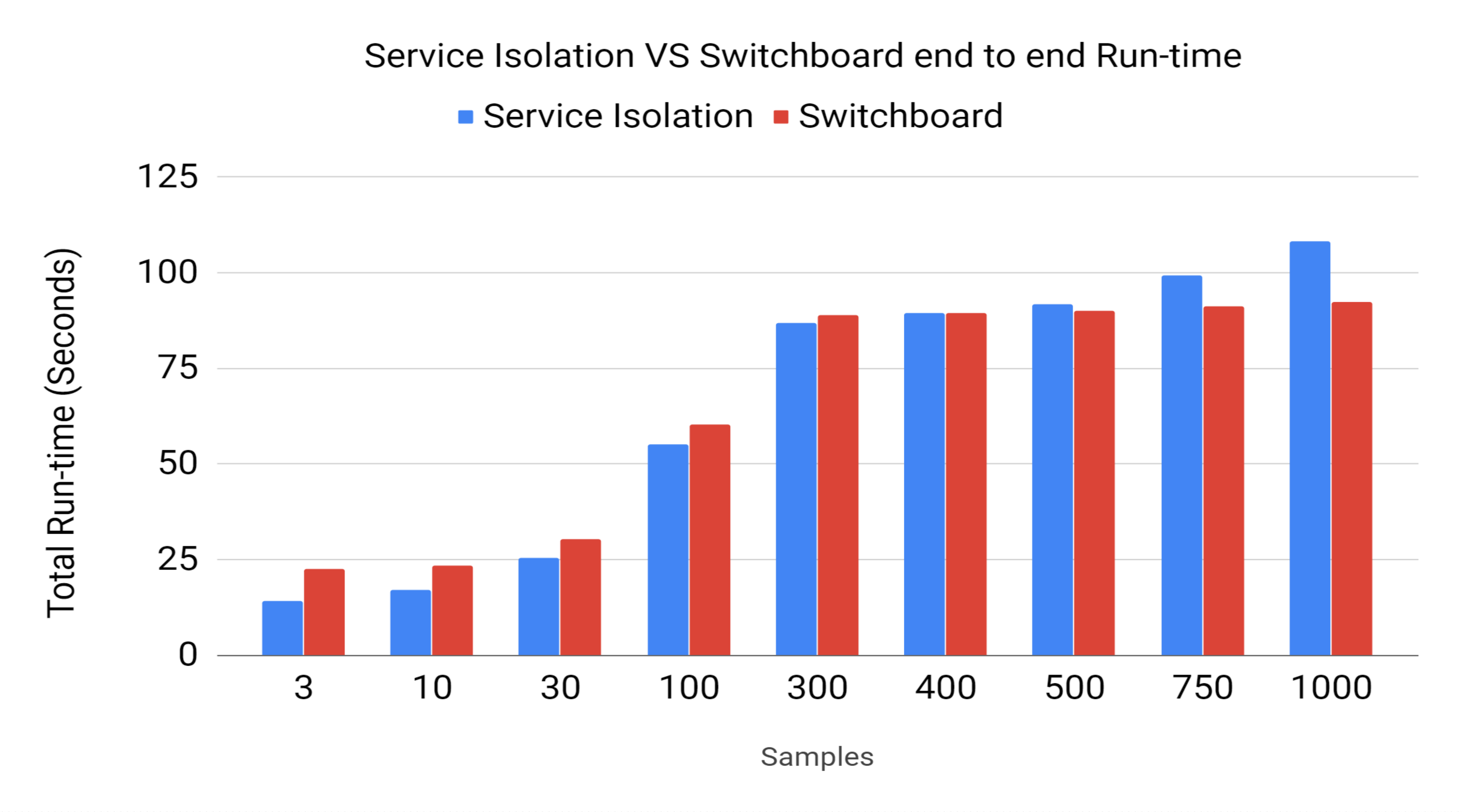
Memory Utilization Service isolation



Composition

How does service composition of microservices impact the application performance?

Performance Comparison



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Conclusions

- Switchboard architecture minimized cold starts
- Switchboard performed more efficiently over larger input dataset sizes vs. service isolation
    - 14.75 % faster for 1,000 samples
    - 17.3% increase in throughput
- When inferencing just 3 samples, the service isolation architecture was faster
    - 36.96% faster for 3 samples
    - 58% increase in throughput
- → ***full service isolation not always optimal***

Questions