SSLShader Accelerating SSL with GPUs

Keon Jang[1], Sangjin Han[1], SeungYeop Han[2], Sue Moon[1] , and KyoungSoo Park[3]
[1]Department of Computer Science, KAIST, {sangjin, keonjang}@an.kaist.ac.kr, sbmoon@kaist.edu
[2]NHN Corporation, haneul0318@gmail.com
[3]Department of Electrical Engineering, KAIST, kyoungsoo@ee.kaist.ac.kr

SSLShader

- SSL-proxy exploiting GPU
  - » Four times faster than CPU-only in terms of TPS
- Offloads cryptographic functions to GPUs
  - » RSA, AES, SHA1
- Opportunistic offloading
  - » Balance loads between CPU and GPU depending on the load
- Implementation
  - » Support TLS1.0 protocol
  - » Support RSA, AES, HMAC-SHA1 cipher suite

Motivation

SSL in today's Internet

- ☺ Secure end-to-end communication
- ☺ Easy to integrate existing applications
- ☺ Popular in security critical web services
- ☹ Consumes huge amount of CPU cycles

General-Purpose Computation on GPUs

- GPUs are widely used for data-intensive workloads
  - » E.g. Medical imaging, bioinformatics, finance, etc.
- High performance with massively-parallel processing

	Price	# of cores	# of HW threads	Peak performance
CPU (Intel Core i7 920)	$260	4	8	43 GFLOPS
GPU (NVIDIA GTX480)	$499	480	23,040	1345 GFLOPS

Design and Implementation

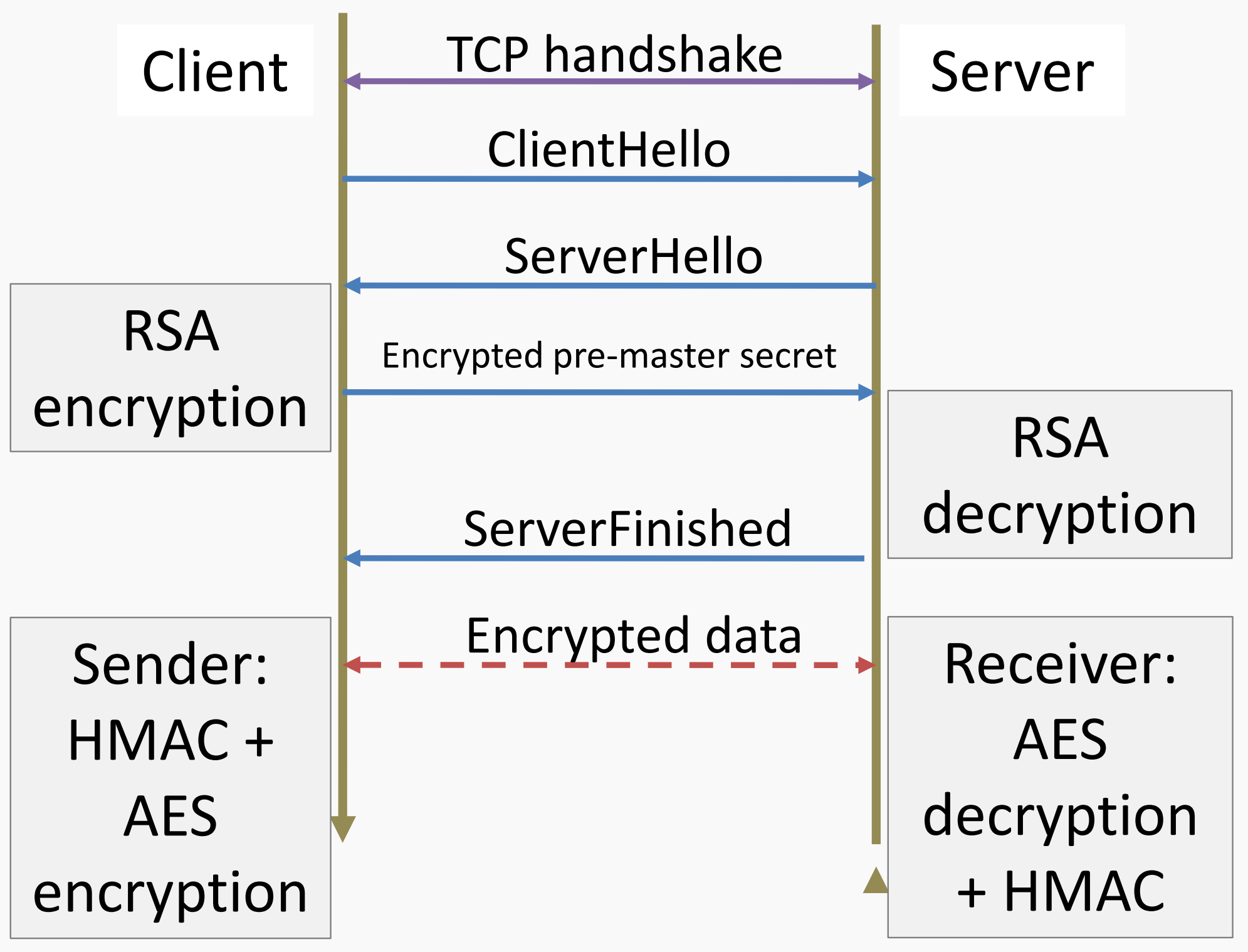
Basic Design

- SSL proxy
  - » No modification on the server
    - » Server uses TCP and proxy tunnels TCP through SSL protocol to client
  - » Many servers behind single proxy
    - » More parallelism with more concurrent connections
    - » Cost-effective in server farms
- Opportunistic Offloading
  - » GPU is not always faster than CPU
    - » GPU requires tens to thousands of same task for max utilization
    - » Single threaded job is slower on GPU
  - » Use GPU only when there's benefit
  - » Minimize latency in light load
  - » More throughput in high load
- NUMA-aware GPU sharing
  - » Scalable with # of CPUs and GPUs
  - » Each core spawns worker thread
  - » GPU is shared by workers in the same Numa-node

Cryptographic Algorithms

- RSA
  - » Secure exchange of secrets under eavesdropping
  - » GPU executes single multiplication of large integer (> 512 bits) in parallel
- AES
  - » Encrypt exchange of data
  - » In CBC-mode, AES-DEC is parallelized in 16-byte block level
- HMAC-SHA1
  - » Prevent tampering of message

Workflow of SSL


Client

Server

TCP handshake

ClientHello

ServerHello

RSA encryption

Encrypted pre-master secret

RSA decryption

ServerFinished

Encrypted data

Sender: HMAC + AES encryption

Receiver: AES decryption + HMAC

Microbenchmarks

- RSA

	1024-bit	2048-bit	4096-bit
GPU	66,970	9,995	1,348
CPU	7,268	1,160	164

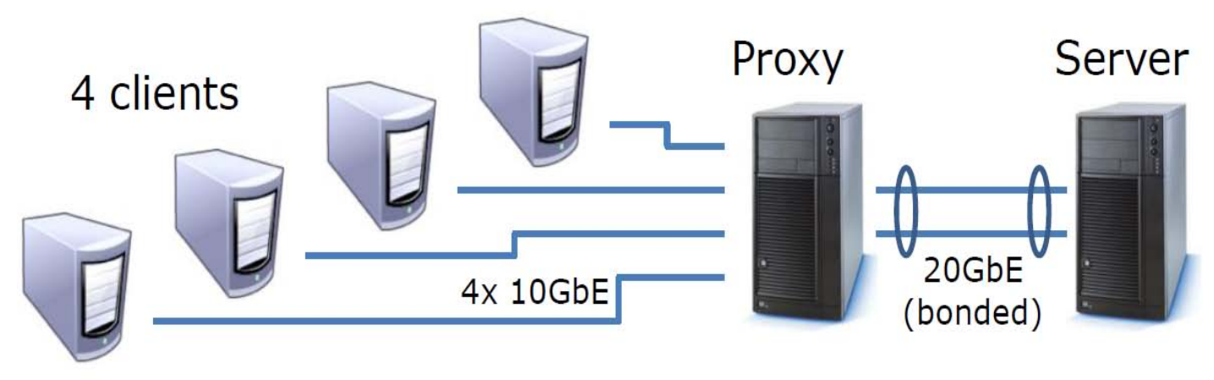
- AES and HMAC-SHA1

	AES-ENC	AES-DEC	HMAC-SHA1
GPU	9,254	9,342	27,863
CPU	4,620	4,620	10,429

RSA unit is msg/s, and AES/HMAC-SHA1 unit is Mbps. GPU is GTX480, and CPU is Intel X5550 (all four cores are used). CPU performance is measured with OpenSSL 1.0.0.

Preliminary Results

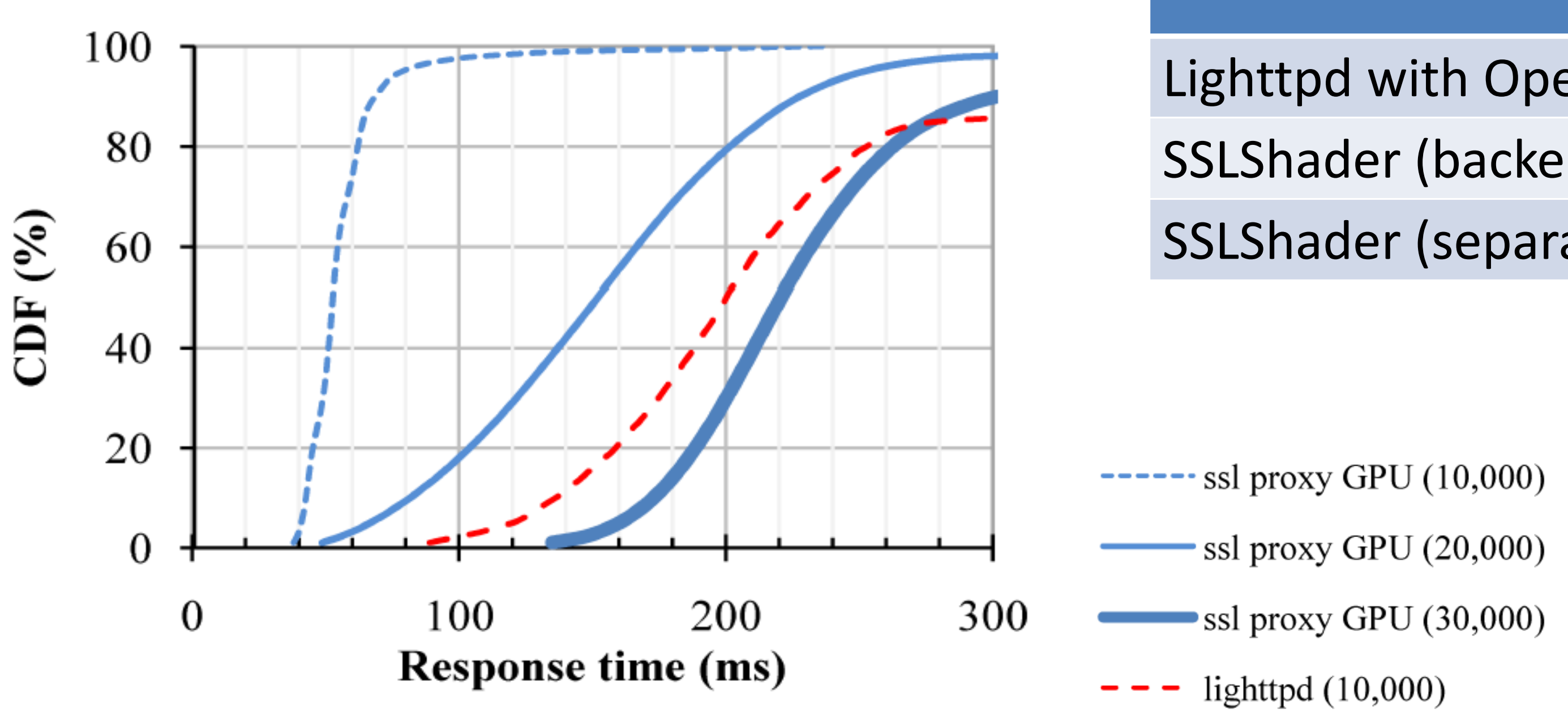
- Experiment Configuration



- Machine Specification

Item	Specification	Qty
CPU	Xeon X5550 (quad-core 2.66GHz)	2
RAM	DDR3 ECC FBDIMM 2GB 1,333Mhz	6
Motherboard	Super Micro X8DAH+	1
Graphics card	NVIDIA GTX480 (480 cores)	2
NIC	Intel X520-DA2 (dual-port 10GbE)	4

- Latency
  - » Measured with 1-byte content size over HTTPS
  - » Number in parenthesis indicates offered load in TPS



- Transactions per seconds
  - » Measured with 1-byte content size over HTTPS

Target	TPS
Lighttpd with OpenSSL (without proxy)	9,246
SSLShader (backend in the same machine)	16,497
SSLShader (separate backend)	25,823

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