Extracting Value from Data: FPGA Acceleration

DAN MCNAMARA
SENIOR VICE PRESIDENT
GENERAL MANAGER, PROGRAMMABLE SOLUTIONS GROUP
ACCELERATING THE DATA-CENTRIC WORLD

DEVICES / EDGE

NETWORK

CLOUD/DATA CENTER

REMOVING DATA BOTTLENECKS WITH FPGA ACCELERATION
IA+ FPGA: ACCELERATING BUSINESS OUTCOMES

Real-time actionable intelligence at the edge
New revenue streams for Communication service providers
Improved total cost of ownership (TCO) in the cloud

FPGA

- HIGH THROUGHPUT I/O
- 1000s OF PARALLEL PROCESSING UNITS
- PROGRAMMABLE

LOWER LATENCY
HIGHER PERFORMANCE
MULTI-FUNCTIONAL
INTEL SCALE DRIVING VALUE AND GROWTH

DATA CENTER AND COMMUNICATIONS

EMBEDDED

YEAR-OVER-YEAR REVENUE GROWTH

<table>
<thead>
<tr>
<th></th>
<th>1H '18</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA CENTER</td>
<td>140%</td>
</tr>
<tr>
<td>ADVANCED PRODUCTS (28NM, 20NM, 14NM)</td>
<td>50%</td>
</tr>
<tr>
<td>TOTAL REVENUE</td>
<td>17%</td>
</tr>
</tbody>
</table>

*Revenue excludes Intel products with integrated FPGAs

2016: $1.8B
2017: $1.9B
2018 (1H): $1.0B
BETTER TOGETHER: SOLUTIONS ACROSS MARKETS

IA+FPGA SOLUTIONS

EDGE/EMBEDDED
Vision Analytics
Smart retail
Industrial (IOT)
Radar/surveillance

ENTERPRISE
Database
AI
Financial
Health Life Sciences

NETWORKING
5G
NFV
Wireline

CLOUD
Networking
Storage
Security
AI
Transcode

IP & ECOSYSTEM

SOFTWARE

SILICON/BOARDS

INTEL PARTNERSHIPS: IP, OEM, SI, ISV, VAR

INTEL+FPGA FLOWS: SOFTWARE-CENTRIC DESIGN METHODOLOGY

HW LEADERSHIP: SILICON, BOARDS, FPGA ACCELERATION CARDS
Desire for lower server overhead

Intel® Xeon® processor cores

Applications
Infrastructure

100/200/400 Gbps

DATA-CENTRIC INNOVATION SUMMIT

#IntelDCISummit
FPGA: BECOMING MAINSTREAM IN ENTERPRISE

INTEL® PROGRAMMABLE ACCELERATION CARD (PAC) WITH INTEL® FPGAS

- DATA ANALYTICS
- AI
- FINANCIAL
- VIDEO PROCESSING
- CYBERSECURITY
- GENOMICS

GROWING LIST OF SOLUTION ACCELERATION PARTNERS

- Abra
- Accelize
- Adaptive Micro-Ware
- Algo-Logic
- b com
- bigstream
- CAST
- CTACCEL
- enyx
- Falcon Computing
- Levyx
- MEGH Computing
- NAGASE NAGASE & CO. LTD.
- Myrtle
- ENIAC
- Swarm64
- PRIMERGY RX2540 M4
- Dell R640, R740, R740xd

*Other names and brands may be claimed as the property of others.*

#IntelDCISummit
END-TO-END SOLUTIONS FOR 5G

1000X CAPACITY INCREASE
5X DECREASE IN LATENCY
EVOLVING 3GPP STANDARDS

5G NETWORK CHALLENGES

1M+ BASEBAND UNITS IN 2022
5M+ RADIO UNITS IN 2022

1. https://www.techworld.com/apps-wearables/what-is-5g-everything-you-need-know-about-5g-3634921/
*mobile experts base station transceiver forecast, 2018
END-TO-END SOLUTIONS FOR NFV

**NETWORK INFRASTRUCTURE**
Physical Appliances

- Single application on dedicated hardware and proprietary management

- EDGE
- EPC
- ROUTER

> TEM/OEM Proprietary OS

ASIC, DSP, FPGA, ASSP

**FLEXIBLE CLOUD INFRASTRUCTURE**
Industry-Standard x86 Servers

- Decoupled software on standard x86 server hardware solution agnostic management

- EDGE
- EPC
- ROUTER

**MANAGEMENT & ORCHESTRATION**

- H/W Accelerators
  - Compute
  - Storage
  - Networking
  - FPGA
ACCELERATING AI WITH FPGA

SI ADVANTAGES
- SUPPORT EVOLVING AI TOPOLOGIES
- HIGH ON-CHIP MEMORY FOR INCREASED THROUGHPUT
- LOW LATENCY INFERENCE
- ENERGY-EFFICIENT INFERENCE

TOOLKITS

OpenVINO™†
Open Visual Inference & Neural Network Optimization toolkit for inference deployment on CPU/GPU/FPGA for TensorFlow®, Caffe® & MXNet®

FOUNDATION

Intel® nGraph™ Compiler
Open-sourced compiler for deep learning model optimizations for multiple devices from multiple frameworks

EDGE

CLOUD / DATA CENTER

Speech/Translation (RNN)

DATA-CENTRIC INNOVATION SUMMIT

#IntelDCISummit
ACCELERATION OF AI FOR EARTH

“WITH MICROSOFT’S AI FOR EARTH PROGRAM WE ARE PUTTING OUR CLOUD AND AI TOOLS IN THE HANDS OF THOSE WORKING TO SOLVE GLOBAL ENVIRONMENTAL CHALLENGES – A TOPIC THAT REQUIRES COMBINING BIG DATA, BIG COMPUTE, AND EFFICIENT ALGORITHMS. DEPLOYING DEEP NEURAL NETWORK MODELS TO FIELD-PROGRAMMABLE GATE ARRAY (FPGA) SERVICES USING MICROSOFT PROJECT BRAINWAVE IS ONE SUPER SIMPLE WAY TO ACHIEVE THIS. RECENTLY WE USED THIS FPGA SERVICE TO PERFORM LAND COVER MAPPING OF THE ENTIRE UNITED STATES, ANALYZING 10 TRILLION PIXELS ACROSS 20 TB OF AERIAL IMAGERY. MICROSOFT PROJECT BRAINWAVE, USING INTEL FPGAS, SCORED THESE 200 MILLION IMAGES IN ENTIRETY IN JUST OVER 10 MINUTES FOR A COST OF $42.”

Microsoft

Doug Burger
Technical Fellow, Azure HW Systems Group
**EASIC ACQUISITION DRIVING MARKET EXPANSION**

- Cost *and* power reduction path for FPGA customers
- Lower NRE cost and time-to-market for ASIC customers
- Scalable technology to provide pathway to cost reduction for 16nm/10nm/7nm FPGA products

**FPGA**
- Programmable Input & Output Blocks can be programmed to do many types of I/O
- Programmable Logic Blocks can be programmed to do many functions
- Massive Amounts of Programmable Routing can be programmed to connect from anywhere to anywhere

**Structured ASIC**
- Fixed Function Input & Output Blocks: single function
- Fixed Function Logic Blocks: single function
- Fixed Routing: point to point interconnect

**1½ THE COST**
**1½ THE POWER**
UNMATCHED CUSTOMER VALUE

FPGA versatility addresses evolving needs of data era

IA+FPGA solutions creating unparalleled customer value

Expanded TAM and end-to-end lifecycle solutions with eASIC acquisition
Statements in this presentation that refer to business outlook, future plans and expectations are forward-looking statements that involve a number of risks and uncertainties. Words such as "anticipates," "expects," "intends," "goals," "plans," "believes," "seeks," "estimates," "continues," "may," "will," "would," "should," "could," and variations of such words and similar expressions are intended to identify such forward-looking statements. Statements that refer to or are based on projections, uncertain events or assumptions also identify forward-looking statements. Such statements are based on management's current expectations, unless an earlier date is indicated, and involve many risks and uncertainties that could cause actual results to differ materially from those expressed or implied in these forward-looking statements. Important factors that could cause actual results to differ materially from the company's expectations are set forth in Intel's earnings release dated July 26, 2018, which is included as an exhibit to Intel's Form 8-K furnished to the SEC on such date. Additional information regarding these and other factors that could affect Intel's results is included in Intel's SEC filings, including the company's most recent reports on Forms 10-K and 10-Q. Copies of Intel's Form 10-K, 10-Q and 8-K reports may be obtained by visiting our Investor Relations website at www.intc.com or the SEC's website at www.sec.gov.

All information in this presentation reflects management's views as of the date of this presentation, unless an earlier date is indicated. Intel does not undertake, and expressly disclaims any duty, to update any statement made in this presentation, whether as a result of new information, new developments or otherwise, except to the extent that disclosure may be required by law.