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INTEROP

The Software in Software Radio

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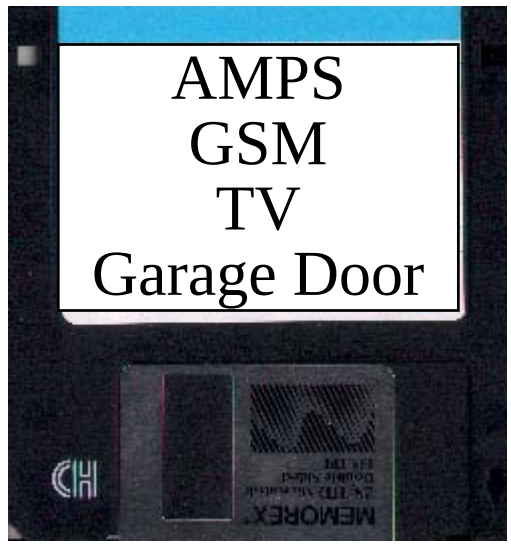
Software Radio

- **Hardware Radio**
  - Separate devices for different functions



- **Software Radio**
  - One device for different functions

Talk Outline

- **Vanu, Inc background**
- **Software Radio technology**
- **Market opportunities**
- **New business opportunities**
- **Is Software Radio a disruptive technology ?**

Company History

- **History**
  - Founded September ‘98
  - Spin-off from MIT SpectrumWare project
  - 20 employees
- **Strengths**
  - 6 years experience implementing software radios
  - Software engineering, DSP, system design
- **Mission**

To be the Software Provider
to the Software Radio Industry.

Why use a Software Radio ?

- **Faster technology tracking**
  - Software-only upgrades to new standards
- **Simplifies user experience**
  - One device for all your wireless needs
- **Mitigates Risk**
  - Can change standard after production
- **Universal Roaming**
  - Between services, standards, providers, countries

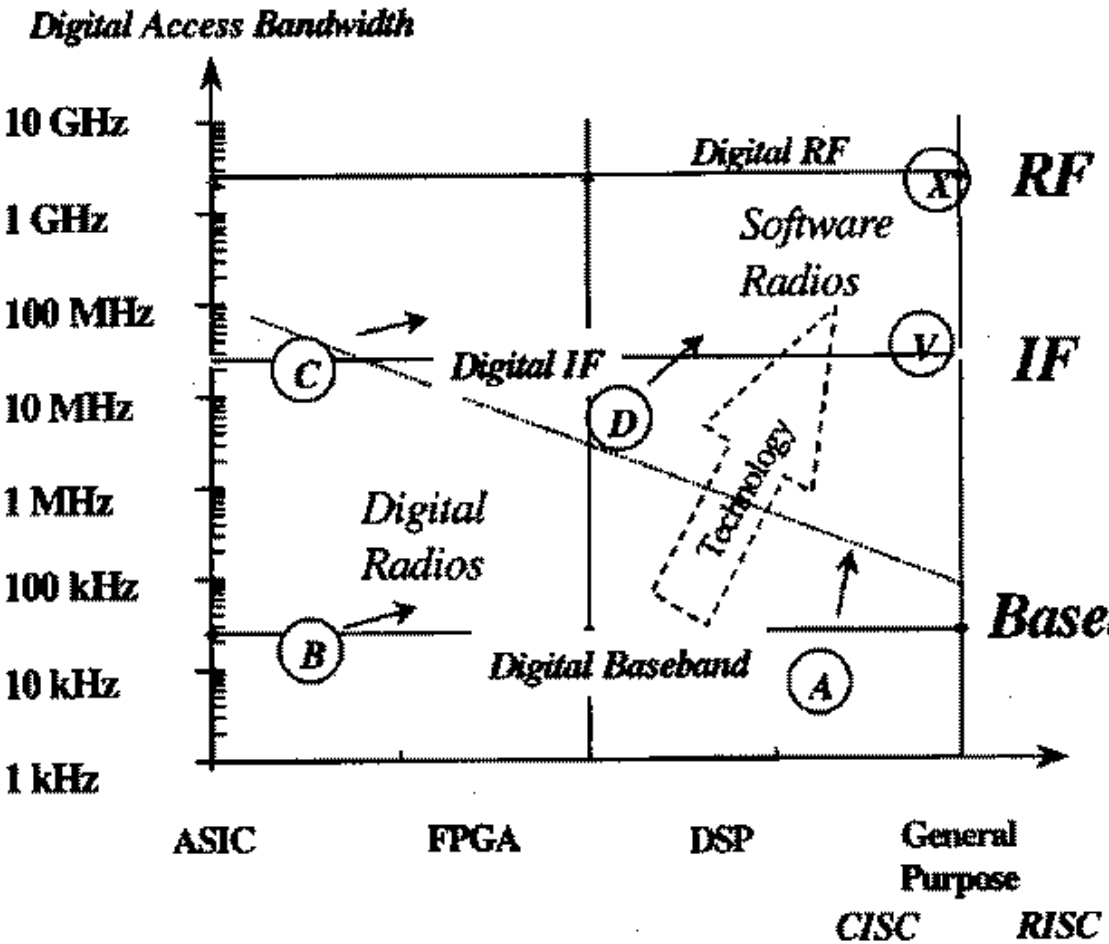
Definition of Terms

- **Software Defined Radio (SDR)**
  - Software controls and configures any aspect of the radio
- **Software Radio (SWR)**
  - Software controls, configures and implements all signal processing functions

SWR is a software problem

- **Manage Software Complexity**
  - Example: Harris Military Radio Family
    - 25 standards, 3 million lines of code
- **Lesson:**
  - Traditional DSP programming approaches will not scale
- **Solution:**
  - Bring CS software engineering to embedded DSP
    - high level languages, objected oriented design
    - software re-use, modularity, portability

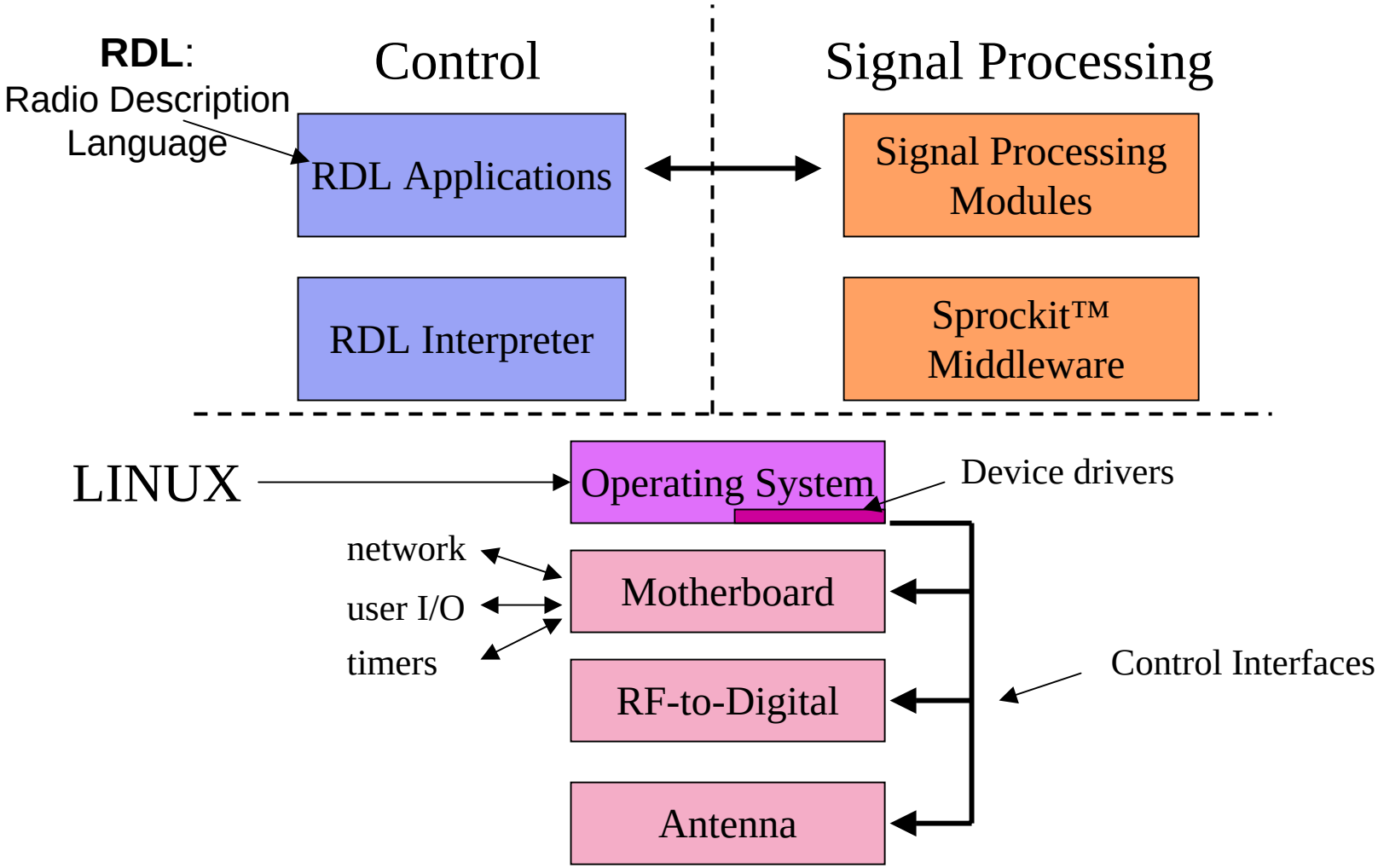
Software Radio Phase Space



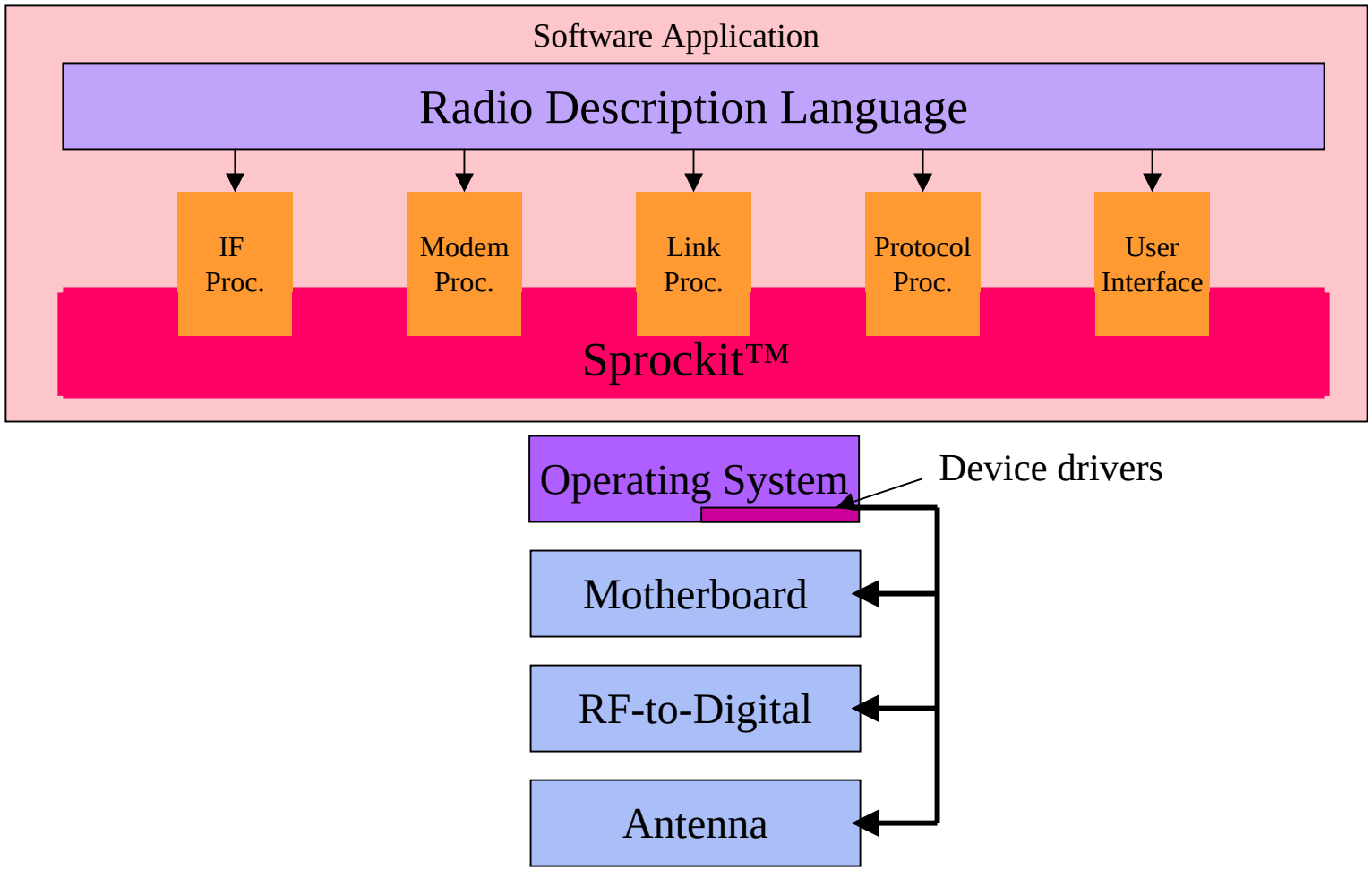
A: HF STR-2000
B: COTS Handset
C: SWR Cell Site
D: SPEAKeasy II
V: Vanu, Inc. Software Radio
X: Ideal Software Radio

Source: Mitola, Joseph. "Software Radio Architecture: A Mathematical Perspective", *IEEE JSAC*, April 1999.

Vanu, Inc. Architecture



Implementation Diagram



Market Opportunities

- **Fixed/Vehicular**
  - Telematics, Fixed wireless CPE, Test and monitoring equipment
- **Wireless Infrastructure**
  - **Requires: scalability and reliability**
  - Cellular / PCS, LMDS, MMDS, Wireless local loop, etc.
  - Shared infrastructure
    - cellular, wireless networks, fixed wireless, public safety
- **Handheld**
  - **Requires: Low power, small form factor**
  - Cellphones
  - PDAs

New Business Opportunities

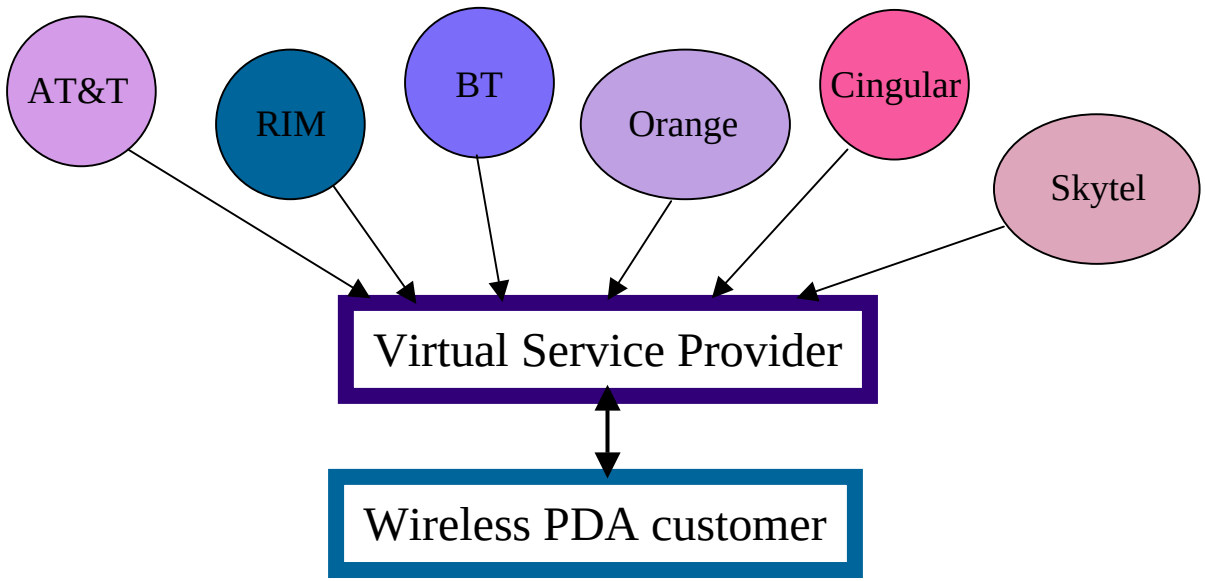
- **Shared Infrastructure**
- **Virtual service providers**
- **Horizontalization of wireless device industry**

Shared Infrastructure

- **One set of infrastructure hardware**
  - Tower, power, network, signal processing
- **Reduce buildout costs by sharing**
  - Est. $10B / carrier for 3G buildout in U.S.
  - Recent activity in Europe to share infrastructure
    - driven by cost of 3G licenses
- **Support multiple customers**
  - Different bands, different standards, different services
    - cellular, PCS, wireless data networks, fleet management, private wireless networks, public safety
    - anyone that uses wireless is a potential customer

Virtual Service Provider

- **Split network operation and service provision**
  - They are fundamentally different businesses
- **Better customer service**
  - Pay one bill, not ten
  - Better coverage and service offerrings



Horizontalization

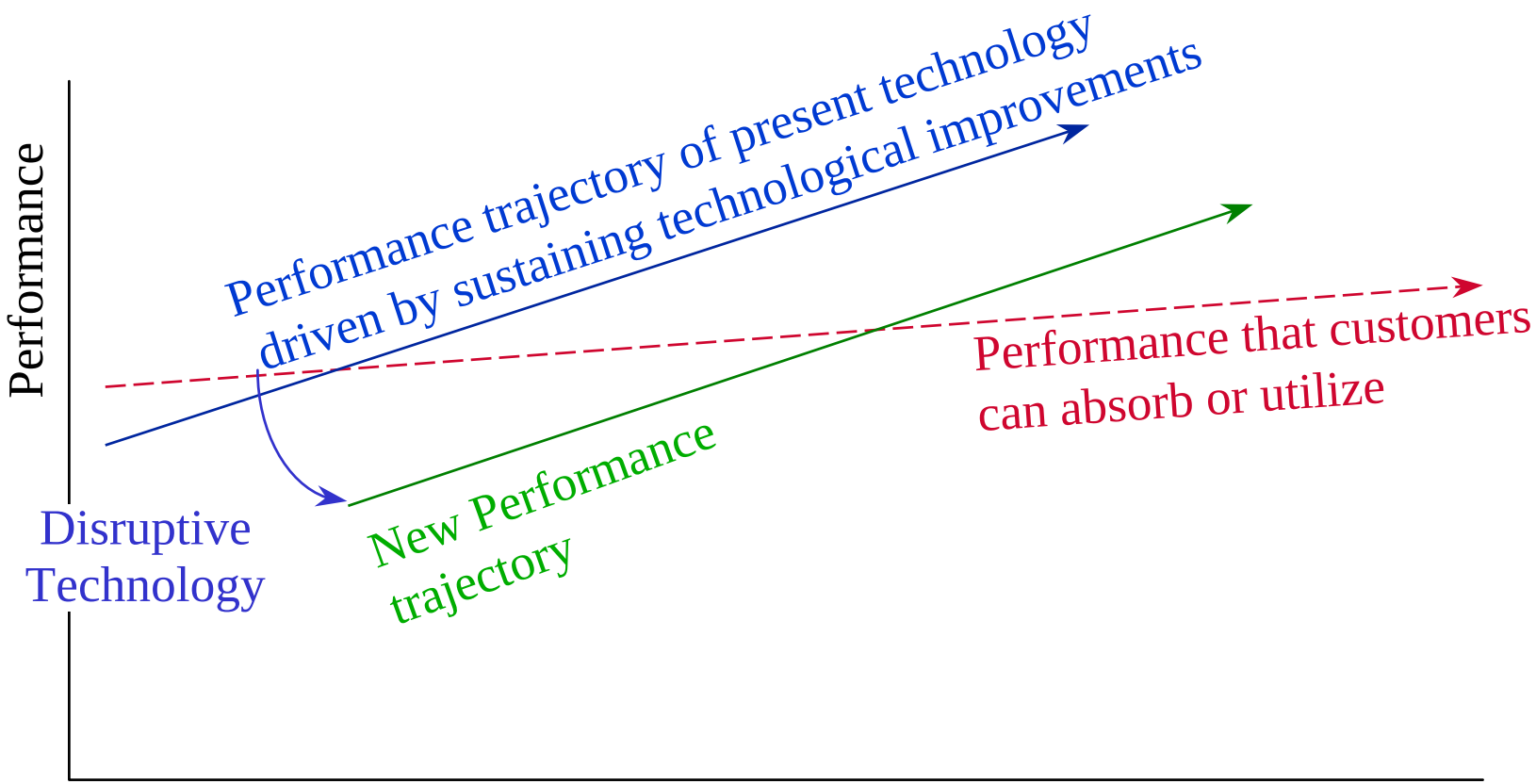
- **Wireless device industry is moving towards a model more like the PC industry.**
- **Software Radio will take it further:**
  - Component suppliers
    - processors, A/D converters, antennas, memory, “motherboards”
  - Software suppliers
    - operating systems, middleware, radio applications
  - System integrators / retailers

    Who will be the Dell of wireless devices ?

Vanu, Inc. Business Model

- **Our Primary Business**
  - Software for Software Radios
- **Our Expertise**
  - Software radio and signal processing software
  - Software radio system design
- **Our Products**
  - System design consulting
    - build prototypes and reference architectures
  - Software licensing
    - middleware, radio applications

Is Software Radio Disruptive ?



Source: Clayton Christenson

Summary

- **Software Radio is an emerging technology**
  - Well suited for vehicular markets
  - Advanced development aimed at infrastructure market
    - scalability and reliability
  - Major limitation for handhelds: battery life
    - limits to niche wireless markets today
    - will be overcome with advances in low power processors
  - FCC examining certification issues
    - proceeding: 00-47
- **Market Implications**
  - Enable new business opportunities
  - Complete the vertical to horizontal industry shift