

VTBO

(Video Traffic Bandwidth Optimization)

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01 Background

- Growth of video traffic leads to data explosion and wireless network resource depletion

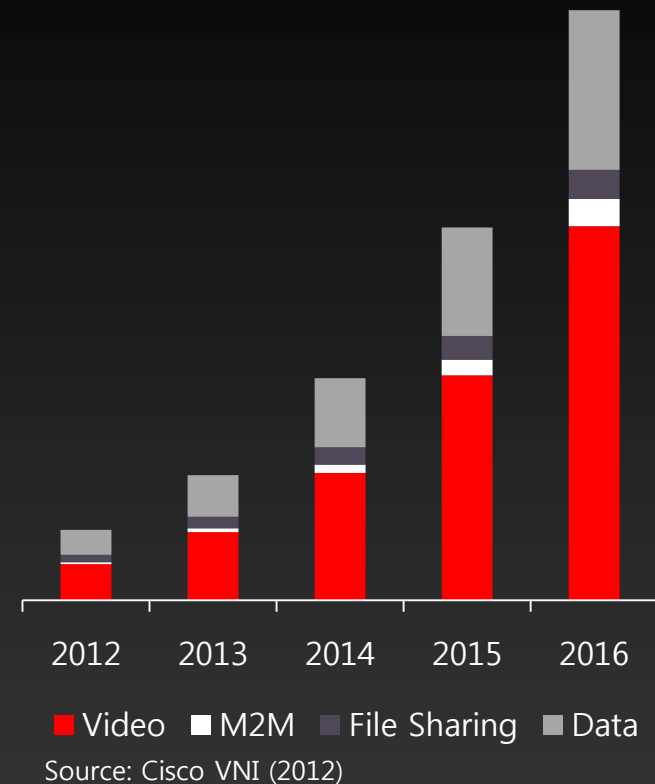
Smart Devices Generate Explosive Video Traffic

- 70% of Mobile Data Traffic to be Video (2016; Cisco)
- KT's mobile traffic increased 300X during the last 3 years

Limitations of Network Investment

- Insignificant revenue growth compared to CAPEX growth
- Scarce spectrum resources

Overall QoE¹ Degradation



¹Quality of Experience

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02 Stakeholders in Video Streaming Face Serious Issues

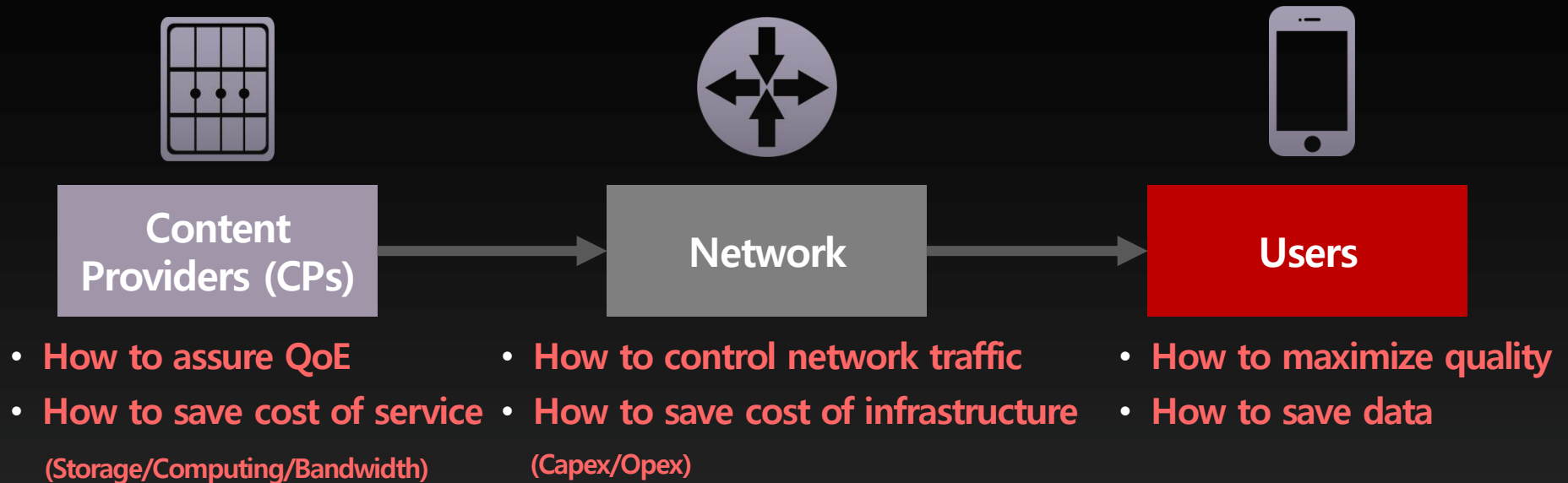
The Current Situation



- Rapid diffusion of smart devices and customers' acceptance for video streaming service resulted in data explosion
- **Customers experience inconvenience such as delays, motion stops, blurred and broken images in video streaming services**

	Concerns	Interim Solution	Issues
Content Providers (CPs)	<ul style="list-style-type: none"> • Low user satisfaction • Fierce Competition 	<ul style="list-style-type: none"> • Adaptive Streaming/CDN • Higher Quality Video Files for Competition 	<ul style="list-style-type: none"> • QoE vs. Cost • Impact of large file size on network congestion • Provision of a single video file for a variety of screen sizes and resolutions
Network	<ul style="list-style-type: none"> • Significant traffic burden on network 	<ul style="list-style-type: none"> • Cache • Capacity Investment 	
Users	<ul style="list-style-type: none"> • Delays in loading • Low level of QoE • Wasted Data 	<ul style="list-style-type: none"> • Better Smart Devices • Switch to another CP 	

03 Issues in Video Streaming



- Need for Video Traffic Optimization Solution
 - Differentiate encoding bit rate for different types of device and content
 - Control video delivery when network is congested

04 Evolution of Video Streaming Technology

Before 2000

Traditional Streaming [UDP]

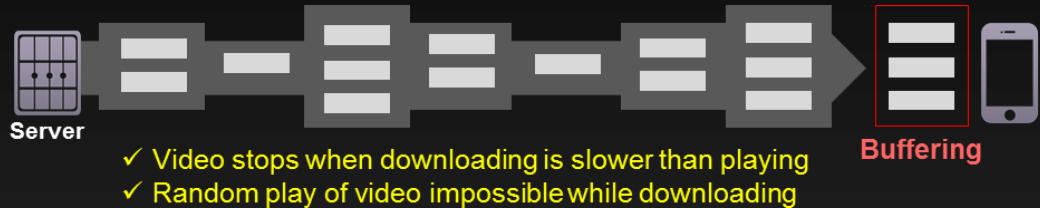
- No guarantee of QoS and in-order delivery
- Flow control not supported



2000s

Progressive Download [TCP]

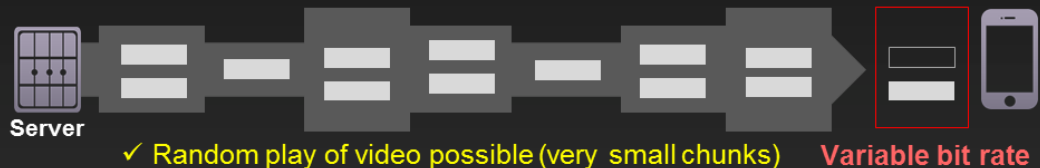
- Can waste bandwidth
- No bit-rate adaptation



2010s

Adaptive Streaming [TCP + Bandwidth adaptation or Real time transcoding]

- High cost of computing and storage resources



- The evolving streaming technologies still have limitations:
 - Video quality not optimized to human perception
 - Not possible to assure video quality when network is congested

➔ Video streaming with network's help should be considered

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05 Video Traffic Bandwidth Optimization (VTBO)

- Proposal to overcome limitations of streaming technologies
 - Optimization of video quality and Priority-based traffic control

Optimize video quality
to prevent bandwidth waste

**Encoding Bit Rate
Guideline**

- Different devices
- Different types of content

Assure video quality
when network is congested

**Video Traffic
Packetizing &
Labeling**

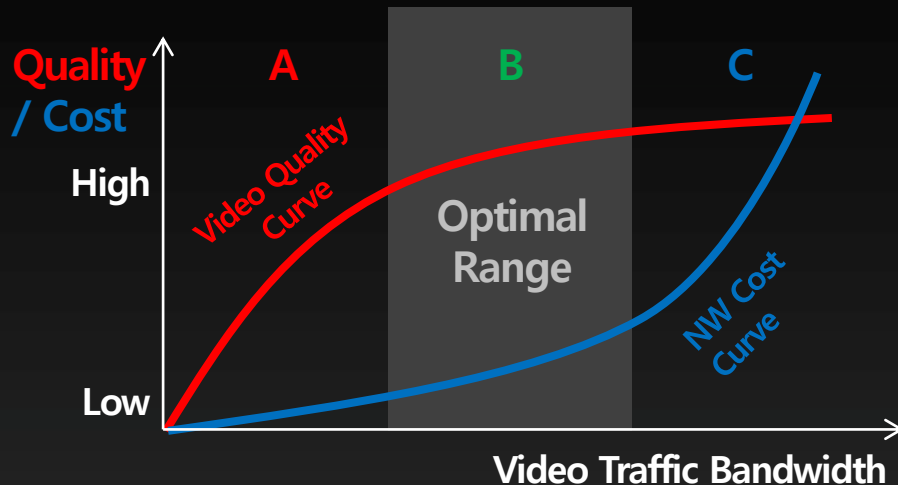
- Priority label

Traffic Control

- Congestion control

06 Optimal Encoding Bit Rate Guideline (1/2)

- Issue: No consideration of device/content types in video encoding



- Non-linear relationship between QoE and bandwidth usage
- Optimal encoding bit rate prevents excessive traffic generation

Suggest optimal encoding bit rate for different types of device/content

➔ Reduce network bandwidth usage

07 Optimal Encoding Bit Rate Guideline (2/2)

- Study in progress by KT and Yonsei University
 - Devices: iPhone 5, Galaxy S4, iPad Retina Display
 - Content types: Documentary, Sports, Drama, etc.

Test Example (Source: Full HD (1080p) 8Mbps Video)

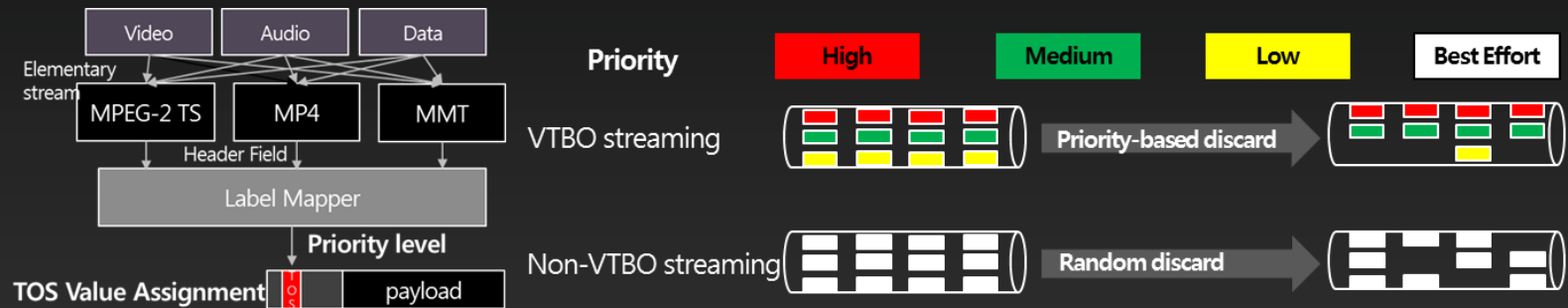
Source	Content Type			Device Type	Encoding Guideline	
Source	Genre	Spatial Frequency	Activity	Device	Video Resolution	Bit Rate (Mbps)
1	Documentary	Medium	Medium	iPhone	540p	4.0
				Galaxy S4	720p	5.0
				iPad	1080p	6.0
2	Sports	Medium	High	iPhone	540p	4.0
				Galaxy S4	1080p	4.0
				iPad	1080p	6.0
3	Drama	High	Medium	iPhone	540p	2.5
				Galaxy S4	540p	2.5
				iPad	720p	3.0
...

- Derived optimal encoding bit rate and video resolution required to have QoE similar to that of the source based on subjective QoE measurements
- Experiment (based on ITU-T 910 standard) conducted for 30 content sources

08 Video Traffic Packetizing and Labeling

- Issue: Difficult to sustain QoE when network is congested

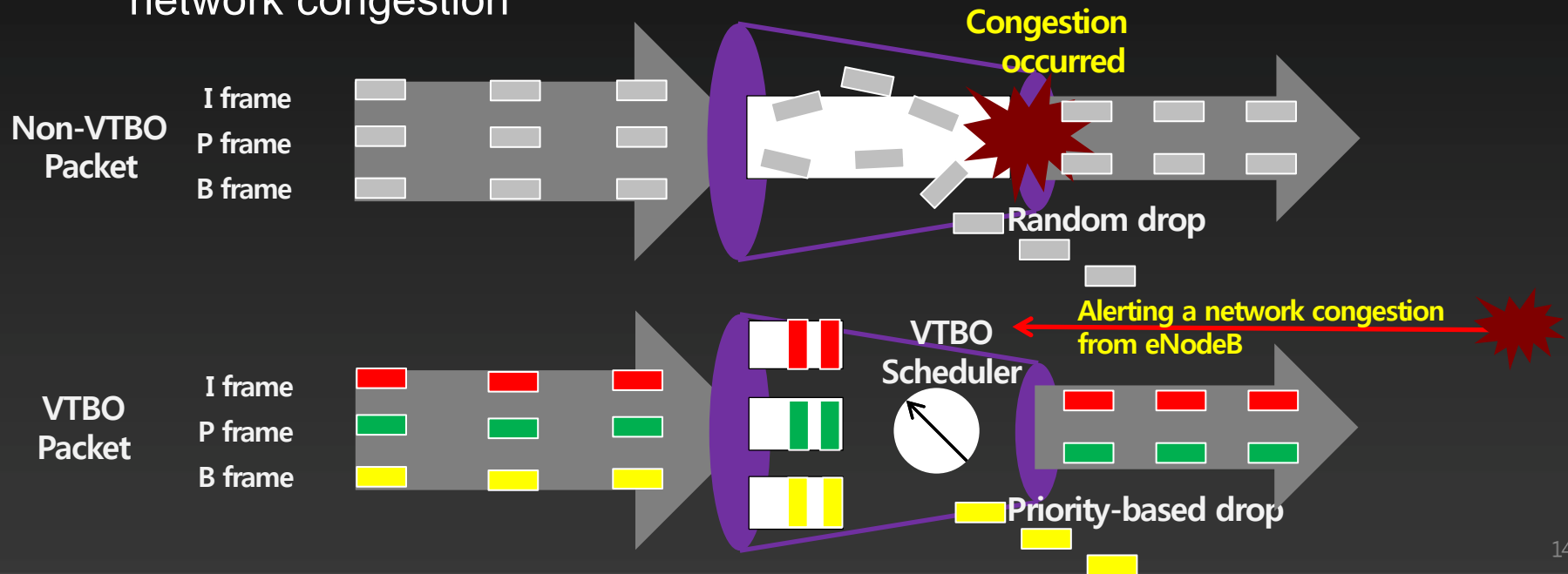
- CPs decide on VTBO priority (High, Medium, Low) of video packets and mark them accordingly
 - Non-VTBO stream: best effort delivery



- Priority-based traffic control is expected to minimize QoE degradation when network is congested

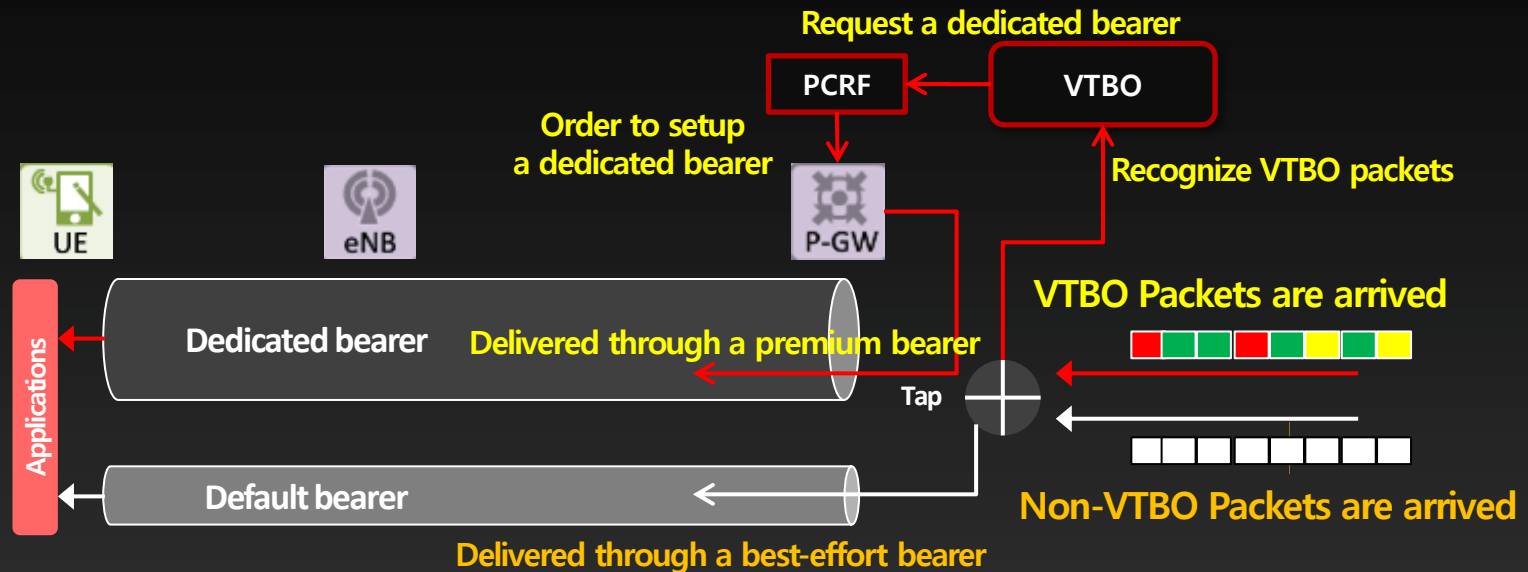
09 Video Traffic Control (1/2)

- Issue: Need for video traffic control during network congestion
- Control with minimal changes in existing network
 - All video packets are delivered when network is not congested
 - VTBO Scheduler controls video packets with priorities during network congestion



10 Video Traffic Control (2/2)

- Provide dedicated bearer with higher QoS for VTBO Streaming



- VTBO is expected to introduce network's control over video delivery

11 Video Quality Comparison: Conventional vs. VTBO



Random Discard



Priority-based Discard

Test conditions

- Original video with bit rate 4Mbps and resolution 480p (640 x 480), 30fps
- Approximately 50% of frames dropped for both cases
- Priority-based discard: only low-priority frames (b-frames) were dropped
- Random discard: frames were dropped randomly

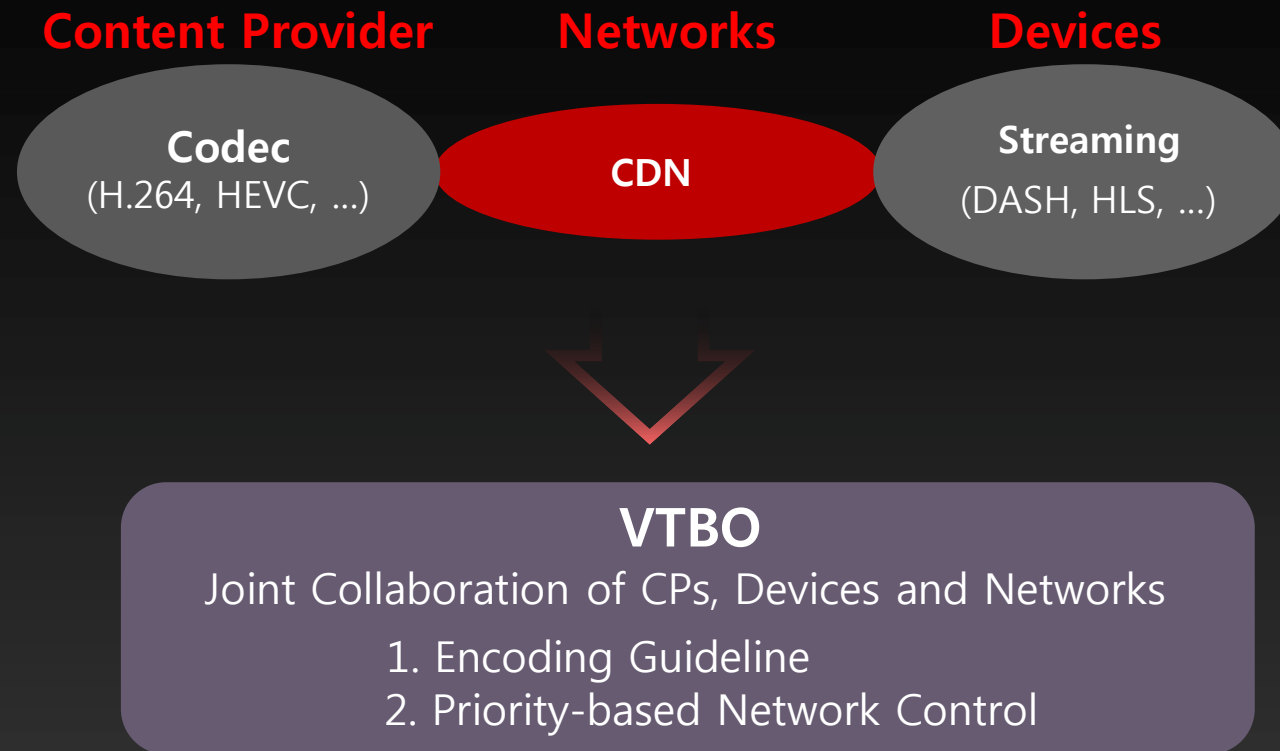
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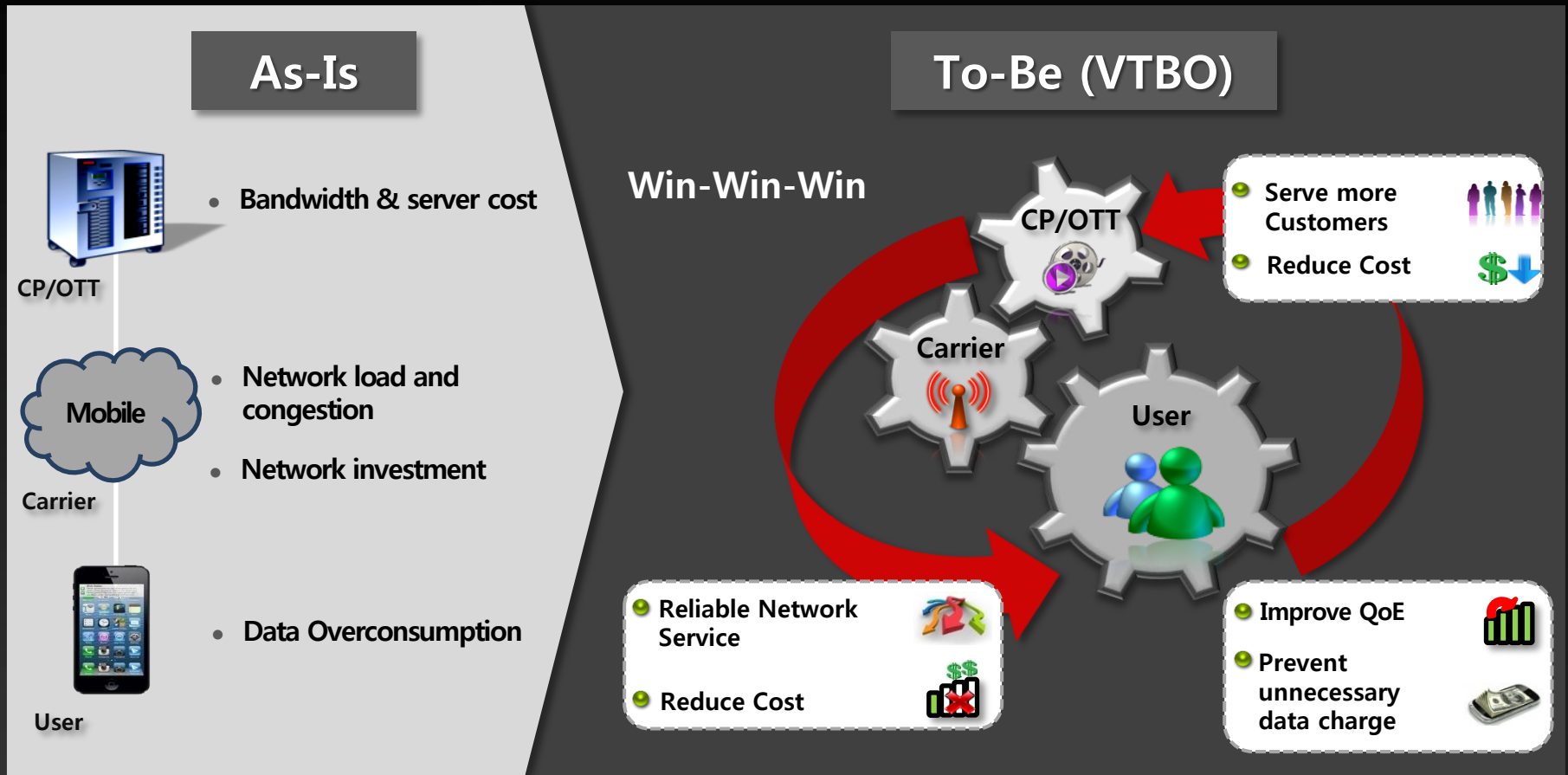
4 Summary

12 Video Traffic Optimization Landscape



Enhance QoE and the efficiency of video streaming

13 Expected Benefits



14 Future Work

Encoding Bit Rate Guideline

- Tests on more variety of devices and video formats (e.g., UHD)

Video Traffic Labeling & Packetizing

- Priority marking mechanism for transport layer

Video Traffic Control

- Methodology to provide different bandwidth for different priorities
- Criterion for traffic control operation

We are trying to make VTBO an international standard

Thank you

