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Operational Transformation

How Cox Communications Implemented an Expert System for Service-First Autonomous Operations

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**VIRTUAL EXPERIENCE
OCTOBER 11-14**

Redesigning Cox Video Encoding in 2015

2015 Platform Refresh Planning & RFP Guided us to Software Video Encoding

- Forecasted need to support emerging technologies and accelerating rate of change
 - MBR, HEVC inputs and outputs, 4K and HDR, ATSC 3 features including enhanced metadata and AC4 audio, etc.
- CPU/GPU advances were closing capacity gap with hardware video encoders

Software Encoding Benefits:

- Agile and Flexible, faster and less disruptive path for upgrades and changes
- Open APIs enable external configuration and operation options
- Common COTS hardware

Cox Video Automation - Ideation

Software Encoding Platforms Opened the Door to API Control

- Automated provisioning
 - Assumed we'd script API calls for every detail to automate building of all streams
 - Also Researched an "Expert System" Automation Solution
- Expert System offers many advanced capabilities
 - State aware with restoration capabilities
 - Programmed with custom business rules and exceptions
 - Designed to mimic how a human expert would operate the platform
- What can we do with this?
 - Automated build operations via a platform defining database
 - Automated operations with fault monitoring and break-fix

Expert System, Service-First Autonomous Operations

Like a self-driving car, an Expert System mimics expert human operators.

An Expert System works to ensure the health of all its services and underlying elements. A “Service-First” Expert System prioritizes its services over restoration of any individual elements.

At Cox, when a fault is detected in a video stream, our Expert System immediately takes informed steps to restore it as fast as possible, before attempting to fix any faulted individual element.

For example, it’s often faster to restore a faulted stream by moving it to an available warm-spare encoder than it is to attempt to fix the faulted component, and then attempting to restore the errored stream.

This method of self-assurance has enabled us to improve the reliability of our video streams, significantly improve MTTR, and reduce the need for additional staffing.

Primary TS Name	Video Template	Network Interface	MUX Group	Audio Input Template	Audio Template	Output Interface	Output
CMT EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_1	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_C
NICK EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_1	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
CARTOON EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_1	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_T
VH1 EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_1	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
CMT West HD	HD_MPEG2_MPTS_1080	eth3	DDTC_2	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_C
NICK West HD	HD_MPEG2_MPTS_1080	eth3	DDTC_2	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
CARTOON WEST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_2	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_T
VH1 West HD	HD_MPEG2_MPTS_1080	eth3	DDTC_2	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
FOOD TV EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_3	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_F
SYFY EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_3	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_S
USA EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_3	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_I
DISNEY EAST HD	HD_MPEG2_MPTS_720	eth3	DDTC_3	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_I
FOOD TV WEST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_4	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_F
SYFY WEST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_4	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_S
USA WEST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_4	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
DISNEY WEST HD	HD_MPEG2_MPTS_720	eth3	DDTC_4	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_D
CNN HD	HD_MPEG2_MPTS_1080	eth3	DDTC_5	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_C
BET EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_5	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
FOX NEWS CHANNEL HD	HD_MPEG2_MPTS_720	eth3	DDTC_5	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_I
E EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_5	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
MTV EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_6	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_I
TNT EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_6	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
FX EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_6	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
AMC EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_6	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_I
MTV West HD	HD_MPEG2_MPTS_1080	eth3	DDTC_7	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_M
TNT WEST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_7	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_T
FX WEST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_7	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
AMC WEST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_7	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_I
TLC EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_8	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
ALLMARK CHANNEL EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_8	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_
HMM EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_8	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_I
BRAVO EAST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_8	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_B
TLC WEST HD	HD_MPEG2_MPTS_1080	eth3	DDTC_9	ENG_SPA_REV2	PASSTHROUGH	eth1 (backup: eth2)	DDTC_

Platform Database

- Flat database file that includes every parameter needed to build hundreds of video streams into our video encoders
- Multicast input and output addresses
- Program names
- Video and Audio Templates
- Network Interface Designation
- Input Filtering, SDT, etc.
- Importing this file into the Expert System initiates the build automation

Template Name	Line ID	Rate Control	Codec	Encoding					
				Definition	Width	Height	Buffer Size	Buffer (ms)	Keyframe Period
HD_MPEG2_MPTS_1080	1	Statmux	MPEG-2	1080i	1920	1080	Standard	NA	1000
HD_MPEG2_MPTS_720	1	Statmux	MPEG-2	720p	1280	720	Standard	NA	1000
HD_MPEG2_SPTS_1080	1	CBR	MPEG-2	1080i	1920	1080	Standard	NA	1000
HD_MPEG2_SPTS_720	1	CBR	MPEG-2	720p	1280	720	Standard	NA	1000
HD_MPEG2_SPTS_720_11200	1	CBR	MPEG-2	720p	1280	720	Standard	NA	1000
HD_MBR_V1	1	CBR	H.264 Main	NA	1280	720	Standard	NA	1000
HD_MBR_V1	2	CBR	H.264 Main	NA	1280	720	Standard	NA	1000
HD_MBR_V1	3	CBR	H.264 Main	NA	768	432	Standard	NA	1000
HD_MBR_V1	4	CBR	H.264 Main	NA	640	360	Standard	NA	1000
HD_MBR_V1	5	CBR	H.264 Main	NA	512	288	Standard	NA	1000
SD_MBR_V1	1	CBR	H.264 Main	NA	640	480	Standard	NA	1000
SD_MBR_V1	2	CBR	H.264 Main	NA	448	336	Standard	NA	1000
SD_MBR_V1	3	CBR	H.264 Main	NA	320	240	Standard	NA	1000
HD_MPEG4_SPTS_1080	1	CBR	H.264 Main	1080i	1920	1080	Standard	NA	1000
HD_MPEG4_SPTS_720	1	CBR	H.264 Main	720p	1280	720	Standard	NA	1000
SD MPEG2 SPTS	1	CBR	MPEG-2	SD	720	480	Standard	NA	1000

Template Name	Line ID	Input ID	Audio Codec	Bitrate	Channels	Sampling Rate	LFE Enabled	Dialog Norm
PASSTHROUGH	1	1	Pass-through	NA	NA	NA	NA	NA
PASSTHROUGH	2	2	Pass-through	NA	NA	NA	NA	NA
MBR_A1	1	1	Dolby Digital Plus	192	Follow Input	48	Yes	-24
MBR_A1	2	2	Dolby Digital Plus	96	Fixed Output (2/0)	48	NA	-24
MBR_A1	3	1	HE AAC	96	Stereo	48	NA	NA
MBR_A1	4	2	HE AAC	64	Stereo	48	NA	NA
ATP_TEST	1	1	Dolby Digital	384	Follow Input	48	Yes	Auto
ATP_TEST	2	2	Dolby Digital	128	Fixed Output (2/0)	48	Yes	NA
AC3_ENCODE	1	1	Dolby Digital	192	Fixed Output (2/0)	48	Yes	Auto
AC3_ENCODE	2	2	Dolby Digital	128	Fixed Output (2/0)	48	Yes	NA

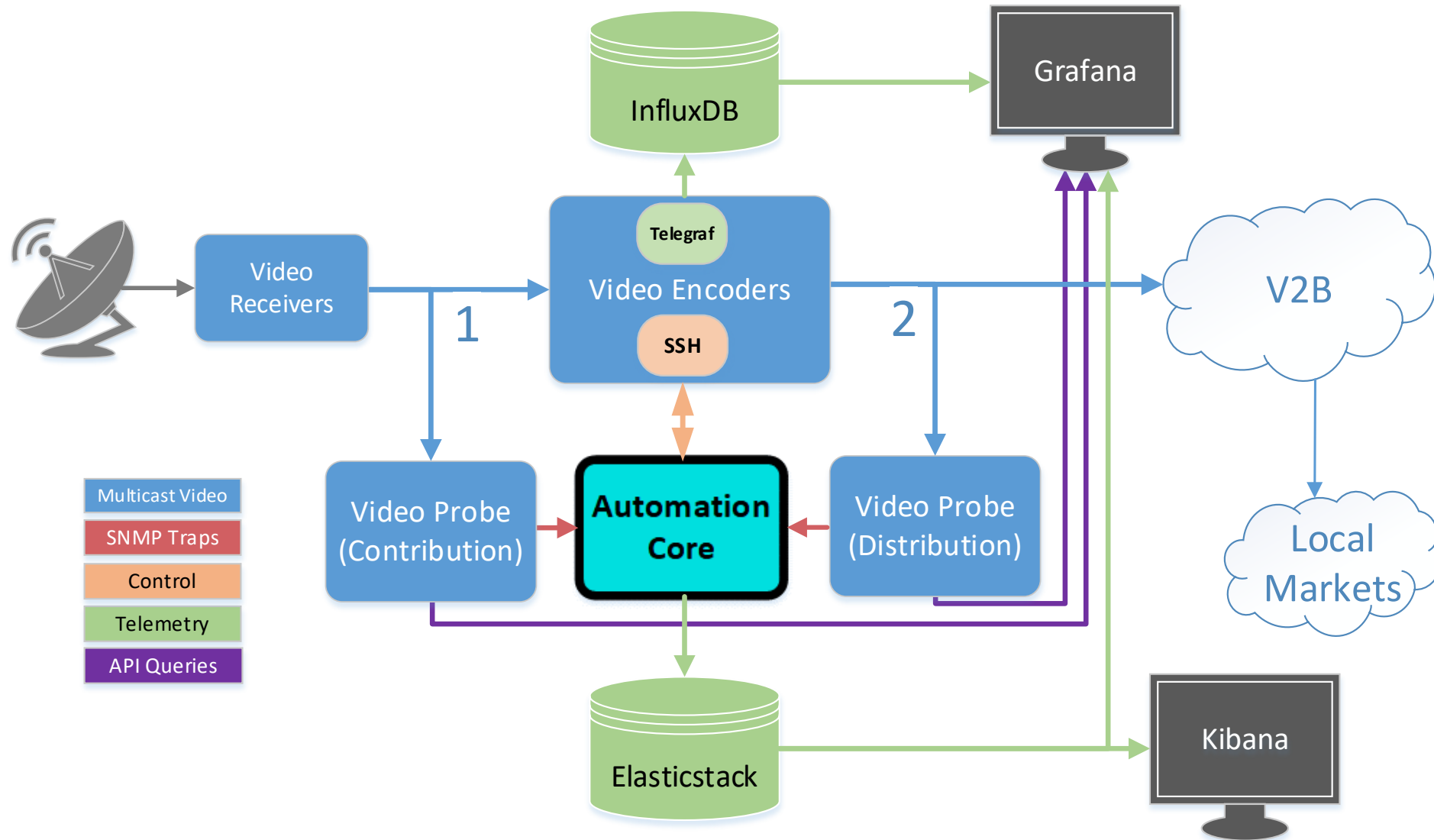
Video and Audio Definitions

Simple Mass-Configuration Changes

- We utilized look-up tables for the highly repetitive audio and video settings based on classes of outputs in MPEG-2 and H.264
 - SD
 - HD 1080i (CBR SPTS and VBR MPTS)
 - HD 720P60 (CBR SPTS and VBR MPTS)
 - Single program AC3 audio
 - Primary and Secondary AC3 audios
 - AAC audio, etc.

Modeling Break-Fix Actions Based on Video Probe Status

Category	Case	DDTC Status			ELC Status		Traps Received	Business Logic	Level 1 Actions	Level 2 Actions
		A Contribution	B Contribution	Distribution	Contribution	Distribution				
Program Detect	1	Green	Green	Green	Green	Green	None	No Traps Received Do Nothing. Continue to monitor	None. Service healthy.	None. Service healthy.
Program Detect	2	Green	Green	Red	Green	Green	Program 508.2	Distribution trap received from Duke. Check issues raised/received from contribution Medius (NONE). Proceed to Level 1 Action for StratOS and if necessary Level 2 Action for StratOS	1. Check status of encoder muse service to determine "running" state IF "RUNNING" 2. Stop and restart alarmed DDTC Muse service (channel). Dwell and recheck. Only Proceed to Level 2 Action for Service Failure on Positive recheck ELSE "STOPPED or UNAVAILABLE"	Service Failure (Channel) - Failover service (channel) spare. OR Encoder Failure- Failover encoder to available spare to remediate failed encoder
Program Detect	3	Red	Red	Red	Green	Green	Program 508.2	Distribution trap received received from Duke. Check issues raised/received from contribution Medius (YES/BOTH Sources). StratOS may issue SOAP call to determine which input is currently ACTIVE. Determination can be made that based on errors on both inputs and output that this is a source issue and StratOS will not automatically remediate. Level1 Action for Operator	OPERATOR - Investigate Duke Contribution flow from RX Proceed to Level 2 Action	Operator uses StratOS portal to suppress channel out will allow downstream failover to El Cajon stream
Program Detect	4	Red	Red	Red	Red	Red	Program 508.2	Distribution traps received from both Duke sources and El Cajon. StratOS treats each Data Center independently and business logic following is same for both. Check issues raised/received from contribution Medius (YES/BOTH Sources). StratOS may issue SOAP call to determine which input is currently ACTIVE. Determination can be made that based on errors on both inputs and outputs that this is a source issue and StratOS will not remediate. Level1 Action for Operator	OPERATOR - Contact Provider	None
Program Detect	5	Green	Red	Green	Green	Green	Program 508.2	Contribution Trap received from Duke B source. Check issues raised/received from Distribution Medius. StratOS may issue SOAP call to determine which input is currently ACTIVE. Since no errors downstream this error is probably indicative of a transport stream failure and Envivio will fail over internally. Level 1 and Level 2 Action for Operator	OPERATOR - Investigate DDTC B Contribution flow from RX	OPERATOR - Verify DDTC service is utilizing A feed, if r input to A feed
		Red	Green	Green	Green	Green		Contribution Trap received from Duke A source.		



Bell Labs Findings

“The Most Advanced Automation System of its Kind We’ve Ever Encountered”

Deployed Capability

- Fulfillment
 - Avoided Investment (NMS)
 - Reduced Incident Management Effort
- Assurance
 - Probe telemetry analyzed for state change policy triggers
 - Closed loop assurance via expert system action and new policy creation

Benefits

- Reduced Eng effort: Fewer Maintenance Windows
 - 0.4 FTE saved (efficiency) per year
- Reduced Eng effort: Incident management
 - 100 in-scope incidents per week
 - 38 minutes saved per incident (T2)
 - 15 Minutes saved per incident (T3)
 - 2.2 FTE saved (avoidance) per year
- Reduced Eng effort: Platform Process savings
 - Cut time to process by 90%
 - 1.9 FTE saved (efficiency) per year
- Reduced Eng effort: Software release upgrade
 - 0.5 FTE saved (efficiency) per year
- Team avoided FTE growth
 - 5.0 FTE saved (avoidance) per year



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Thank You!

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