



VitalCore: Analytics and Support Dashboard for Medical Device Integration

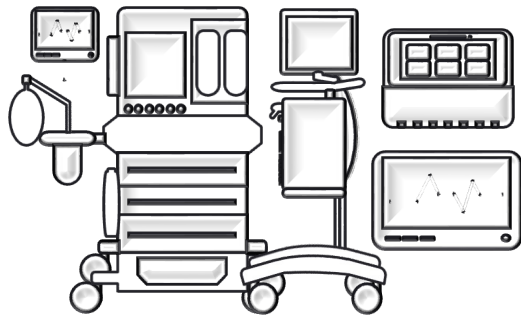
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Amanda Watson^{*}, James Weimer^{*}, Insup Lee^{*}

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Medical Device Integration at Penn Med

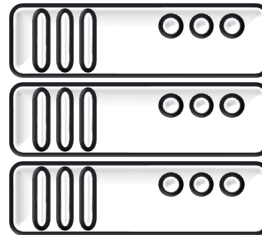
3000+

Integrated Medical Devices



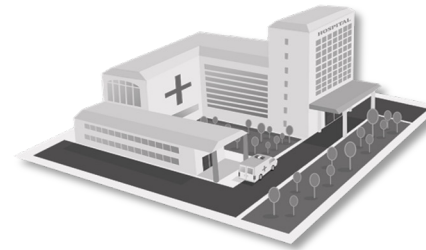
36

HL7 Servers



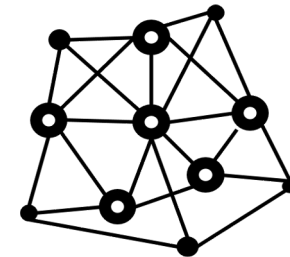
13

Facilities



7

Vendor Networks



When these devices malfunction

Reactive Troubleshooting



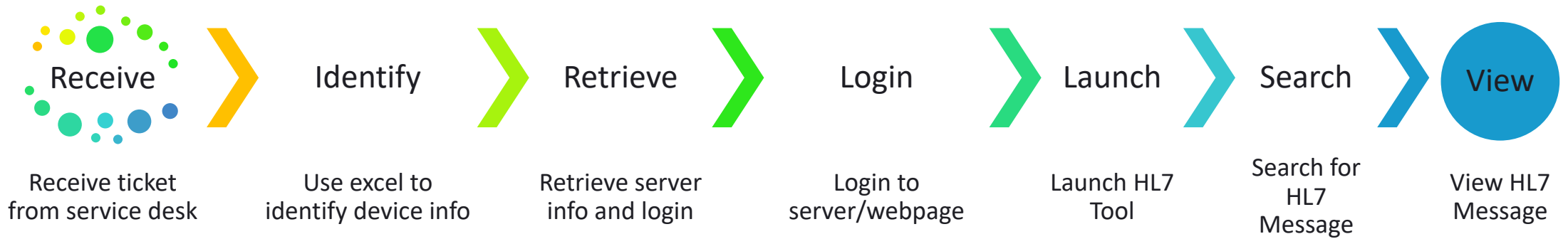
**Extended
Downtimes**

Manual Documentation

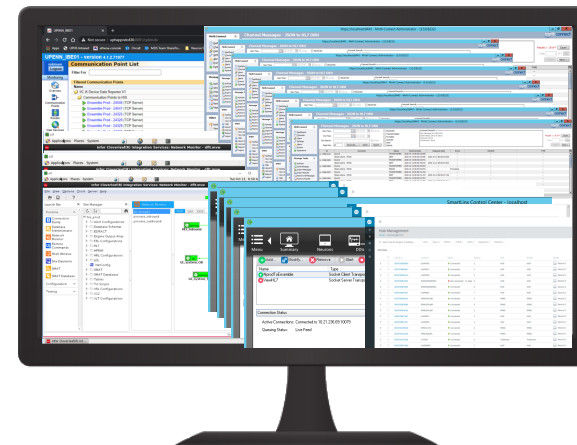


- **Errors**
- **Manipulations**
- **Omissions**

Troubleshooting



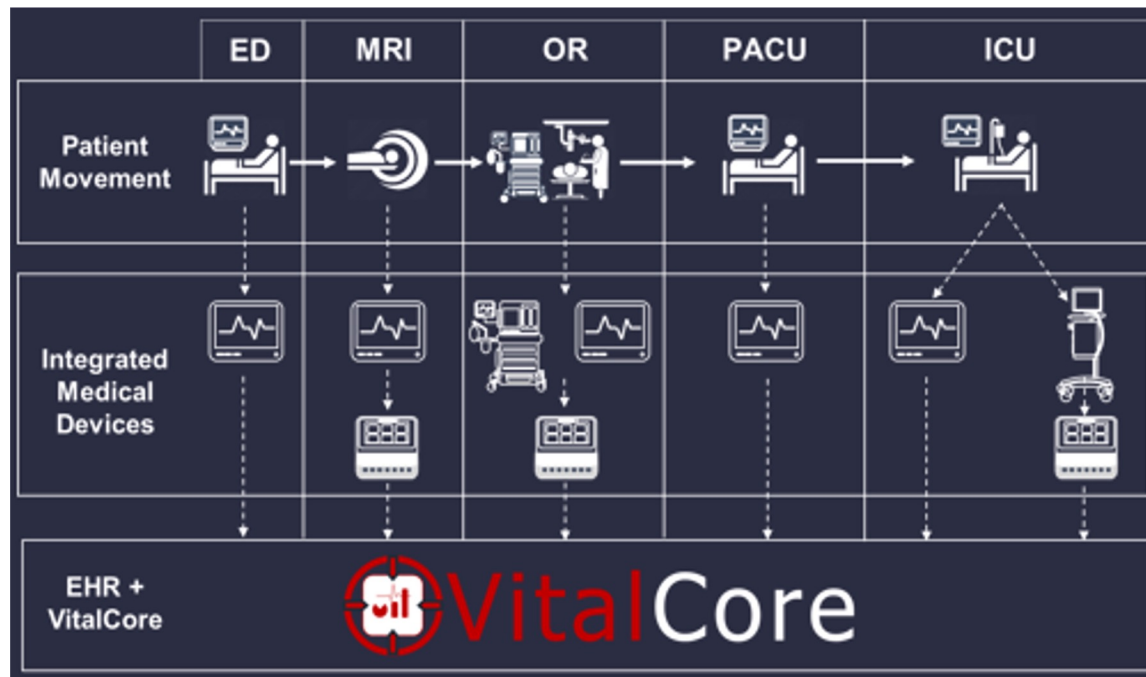
Site	Building	Floor	Rooming Unit/Dept	Room/Prod/Qty	Vendor/Type/Mod	Monitor Model	Net Label	Network ID	Net IP	Response in Busnet	Response in
CCU	East	3	CCU	1	Philips	MP90	CV0001	n/a	n/a	no	n/a
CCU	East	3	CCU	2	Philips	MP90	CV0002	n/a	n/a	no	n/a
CCU	East	3	CCU	3	Philips	MP90	CV0003	n/a	n/a	no	n/a
CCU	East	3	CCU	4	Philips	MP90	CV0004	n/a	n/a	no	n/a
CCU	East	3	CCU	5	Philips	MP90	CV0005	n/a	n/a	no	n/a
CCU	East	3	CCU	6	Philips	MP90	CV0006	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	100	MP90	MP90	1500	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	101	MP90	MP90	1501	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	102	MP90	MP90	1502	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	103	MP90	MP90	1503	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	104	MP90	MP90	1504	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	105	MP90	MP90	1505	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	106	MP90	MP90	1506	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	107	MP90	MP90	1507	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	108	MP90	MP90	1508	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	109	MP90	MP90	1509	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	110	MP90	MP90	1510	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	111	MP90	MP90	1511	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	112	MP90	MP90	1512	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	113	MP90	MP90	1513	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	114	MP90	MP90	1514	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	115	MP90	MP90	1515	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	116	MP90	MP90	1516	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	117	MP90	MP90	1517	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	118	MP90	MP90	1518	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	119	MP90	MP90	1519	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	120	MP90	MP90	1520	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	121	MP90	MP90	1521	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	122	MP90	MP90	1522	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	123	MP90	MP90	1523	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	124	MP90	MP90	1524	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	125	MP90	MP90	1525	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	126	MP90	MP90	1526	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	127	MP90	MP90	1527	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	128	MP90	MP90	1528	n/a	n/a	no	n/a
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CCU	Labco	3	Med Surg	130	MP90	MP90	1530	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	131	MP90	MP90	1531	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	132	MP90	MP90	1532	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	133	MP90	MP90	1533	n/a	n/a	no	n/a
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CCU	Labco	3	Med Surg	135	MP90	MP90	1535	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	136	MP90	MP90	1536	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	137	MP90	MP90	1537	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	138	MP90	MP90	1538	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	139	MP90	MP90	1539	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	140	MP90	MP90	1540	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	141	MP90	MP90	1541	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	142	MP90	MP90	1542	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	143	MP90	MP90	1543	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	144	MP90	MP90	1544	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	145	MP90	MP90	1545	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	146	MP90	MP90	1546	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	147	MP90	MP90	1547	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	148	MP90	MP90	1548	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	149	MP90	MP90	1549	n/a	n/a	no	n/a
CCU	Labco	3	Med Surg	150	MP90	MP90	1550	n/a	n/a	no	n/a



Taking Upwards of 5.5 minutes

VitalCore

Web-based dashboard for medical device integration analytics and support

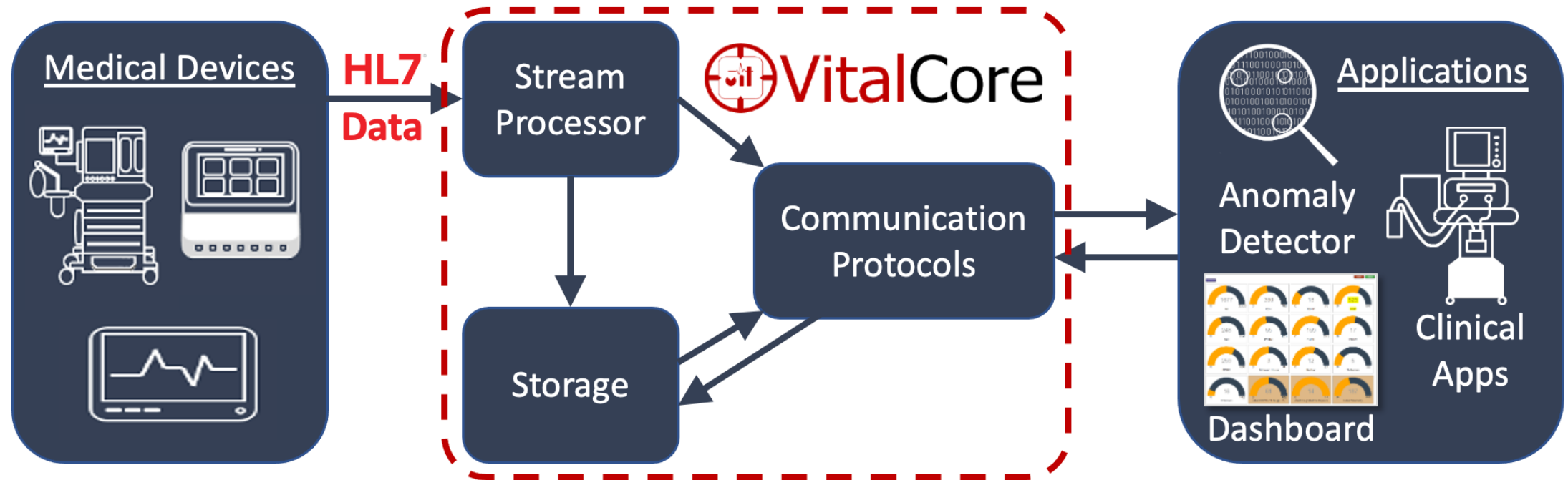


FEATURES

- **Identify all medical devices on the network**
- **Monitor connectivity status of all integrated medical devices in real time**
- **View HL7 data output from all devices, no matter the vendor**
- **Use existing hospital hardware and network infrastructure**

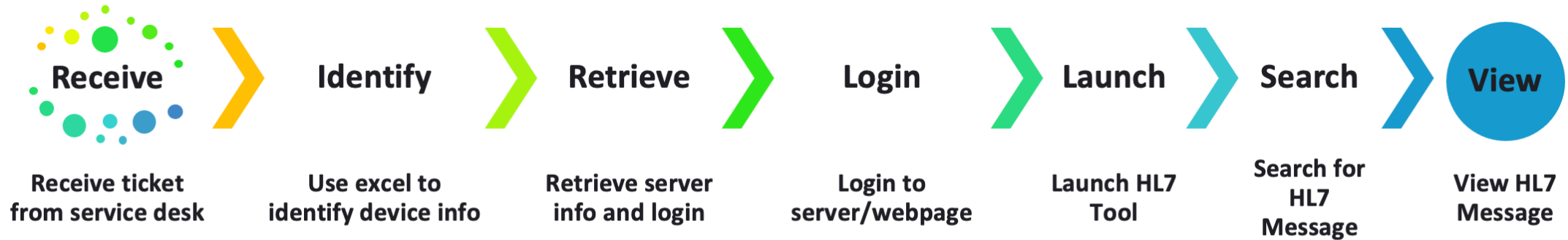
View connectivity and data output from all integrated medical devices on the hospital network, no matter the device type, vendor, or location

System Architecture



Troubleshooting

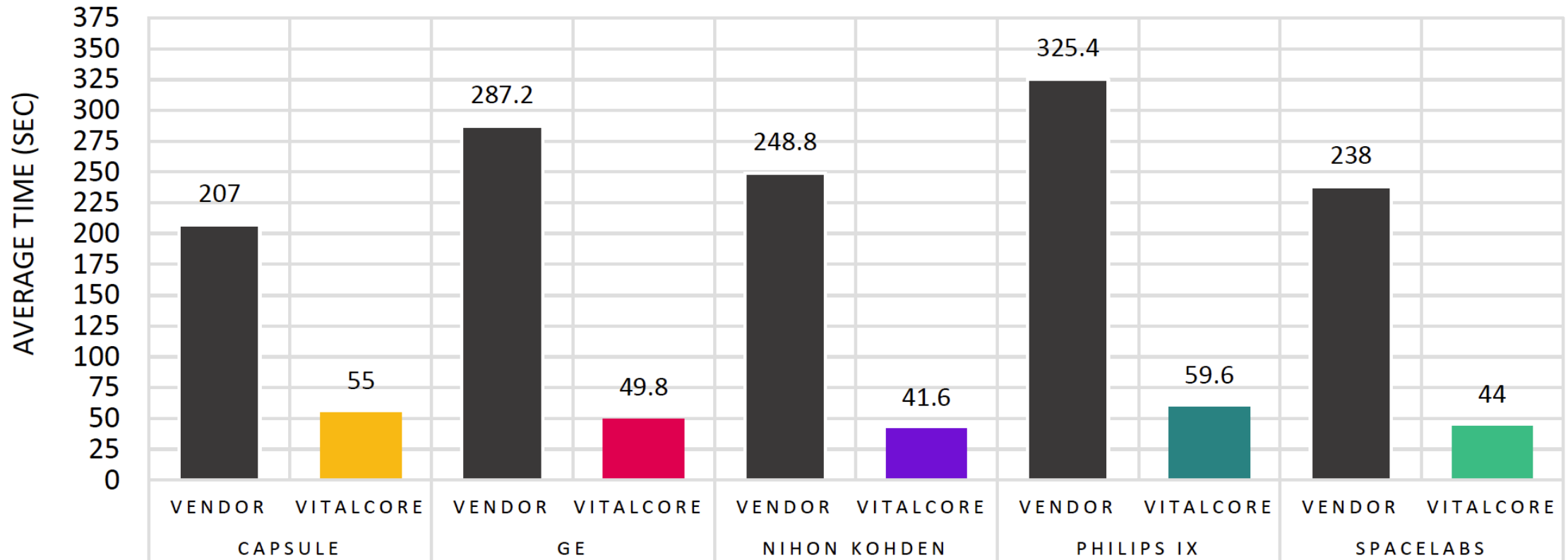
Before VitalCore



After VitalCore



Evaluation - Troubleshooting



3.8 to 6x faster to retrieve HL7 Messages

Anomaly Detection

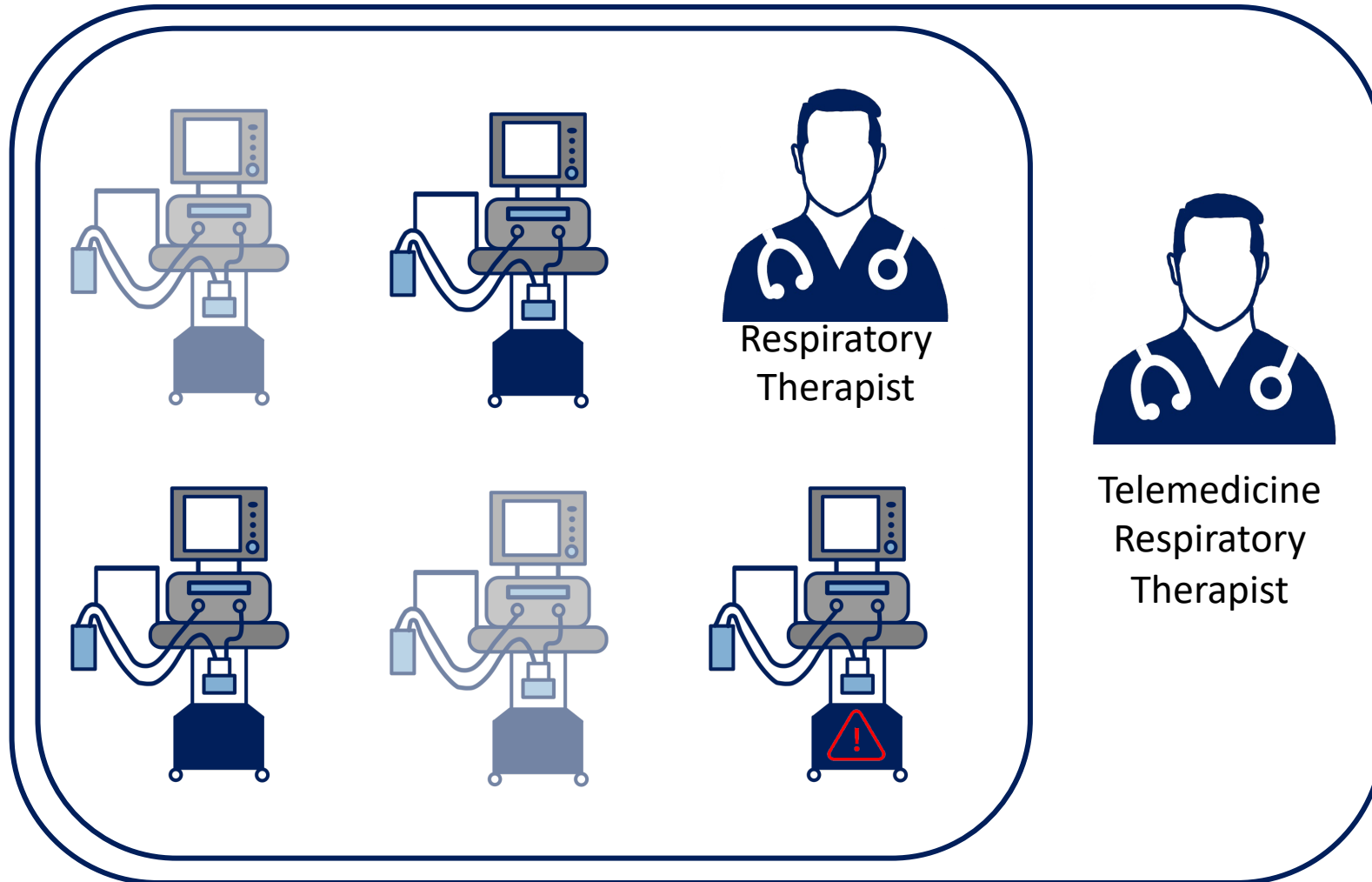


	ACC	F1	PRE	REC	FPR	FNR	T
Autoencoder	0.93	0.87	0.84	1.00	0.08	0.00	787.41
1-class SVM	0.81	0.57	0.42	1.00	0.21	0.00	280.04
Matrix Profile	0.99	-	0.00	0.00	0.00	1.00	295.88
tsmoothie	0.99	-	0.00	0.00	0.00	1.00	-



Detected Anomalies:

- Single and Groups of Devices
- Minute, Day, Weekday, Weekend, Week, Monthly

Ventilation Alert

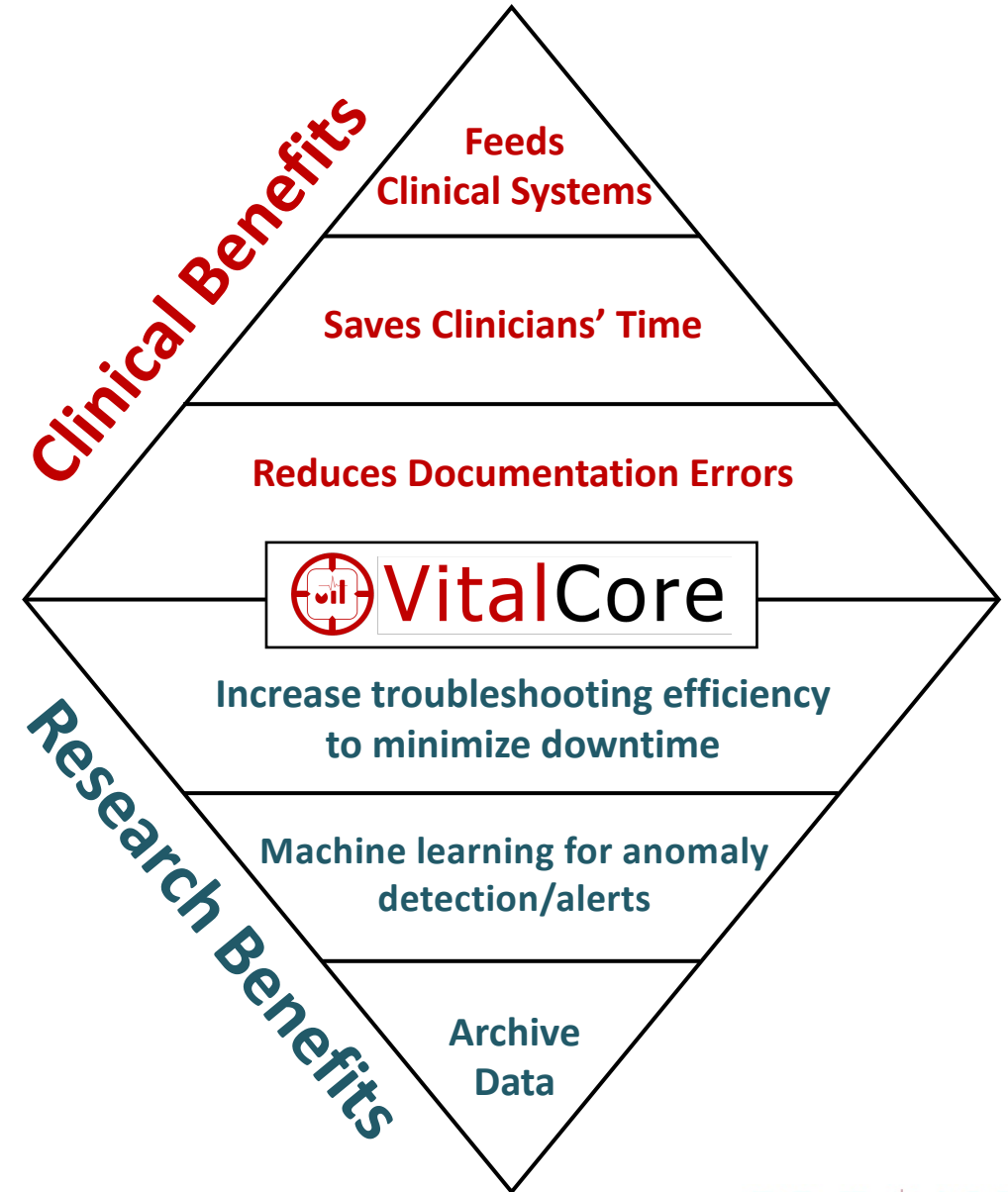


Related Systems

	 SquaredUp	MEDIGATE	capsule [™]	 VitalCore
Device Connectivity Status	X	X	X	X
Medical Device Centric		X	X	X
HL7 Viewer			X	X
Hardware Requirement				
Realtime			X	
Anomaly Detection/Alert System				

Conclusion

- VitalCore is a medical device integration platform that supports clinical decisions
 - Reduces manual documentation of medical device data
 - Provides access to real-time, accurate data in the EHR
- Deployed in 3 real world applications at Penn Medicine:
 - Medical Dashboard, reduced the amount of time required of medical professionals, clinical engineers, and IT analysts by up to six times when troubleshooting.
 - Ventilation Alert extracted ventilation information and alerted appropriate personnel.
 - Anomaly Detector detected anomalies in device usage to change troubleshooting responses from reactive to proactive.



THANK YOU!

PRECISE

PENN RESEARCH IN EMBEDDED COMPUTING AND INTEGRATED SYSTEMS ENGINEERING

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