Venus-C
Virtual multidisciplinary EnviroNments USing Cloud infrastructures

Intensive Care Cloud (ICCloud)

Venus-C pilot application

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Intensive Care Cloud - **ICCloud**

- Led by the Internet Computing Lab / University of Cyprus (http://www.grid.ucy.ac.cy)
- **Problem Target**
  - ICU Patient monitor at any time any place.
  - Identification of similar clinical episodes in a knowledge database.
  - Protect and Secure Private Data.
- **Objectives**
  - Overcome storage and computational capabilities.
  - Design the parallelization model for data analysis .
  - Create public repositories of non-Private Health Information.

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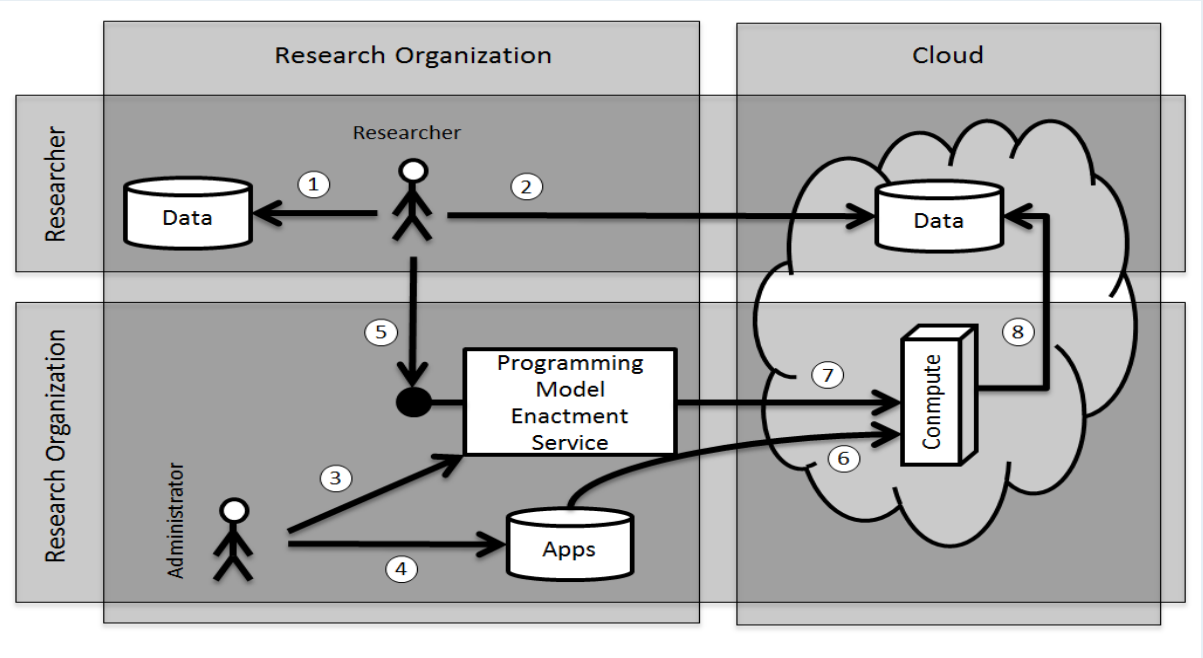
  - Overcome storage and computational capabilities.
  - Design the parallelization model for data analysis .
  - Create two individual data repositories to uphold Private and Non-Private Health Information.

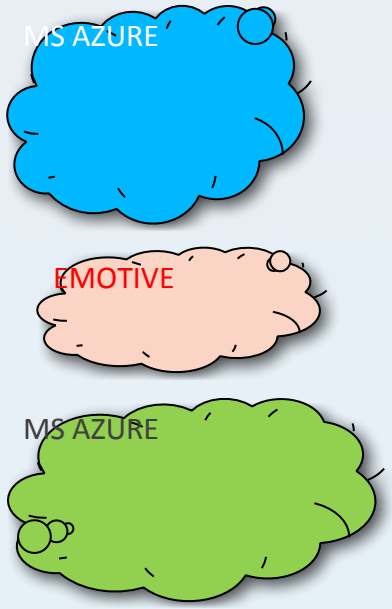
ICCloud
User Community and Benefits

- User Community
  - ICU **medical practitioners.**
    - using real time processing functionality and data annotation feature.
  - ICU **medical trainees** and ICU **medical researchers**
    - using scenario playback and post analysis services.
- Why the “Cloud”?
  - Take advantage of simple storage schemas (blobs, tables, local storage) (or in the future design more complex data associations via SQL server)
  - Job submission without long queue delays.
  - Deliver a Software as a Service solution (second phase of development) to reduce end-user application management overhead (installations, configuration, customization, etc).

Venus-C Architecture

- Why Venus – C?
  - VENUS-C aims to develop, test and deploy an industry-quality, highly-scalable and flexible Cloud infrastructure to empower researchers through the easy deployment of end-user services
  - Enables the usage of multidisciplinary cloud infrastructures.
  - Hides deployment details.





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Venus – C Partners

Project Management

ENGINEERING INGEGNERIA INFORMATICA

Resource Providers

Microsoft Research

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

KTH VETENSKAP OCH KONST
PDC Center for High Performance Computing

Technical Management

Microsoft Innovation Center Europe

Microsoft Innovation Center - Greece

UNIVERSIDAD POLITECNICA DE VALENCIA

User Scenarios

Centre for Computational and Systems Biology

collaboratorio
Venice Gateway for Science and Technology

Newcastle University

Technion Israel Institute of Technology

OGF.eeig european economic interest group

University of the Aegean Department of Geography

National Research Council of Italy

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VENUS-C CLOUD INFRASTRUCTURES

OpenNubula

KTH, 16 computing nodes

ENGINEERING, 4 servers

Supercomputer (BSC)

134 PowerPC CPUs and 9.3 TB

Emotive

90,000 CPU hours per year and **600GB** of storage

MS AZURE (Microsoft)

8,000,000 CPU hours and **10,000 GB** of storage per year

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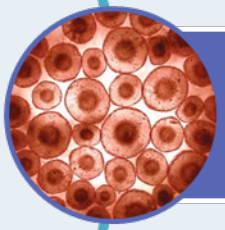
VENUS-C Use Cases
The top 15 Pilots Selected

VENUS-C has also provided seed funds for 15 pilots with applications spanning biology, bioinformatics, chemistry, earth sciences, maritime surveillance, mathematics, medicine and healthcare, physics and social media.

Basic Sciences

- CAD
- CALCIUM
- CLOUD-QUAKE
- PARSEC
- CloudERT
- cTQm



Bio Scienes

- IC-Cloud
- MoDoC
- ScaBIA

Engineering

- AOLBSD
- Bio-CIRRUS
- Cloud4Trends
- ImPrOV
- TARCLOUD
- TRVeC

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Which Infrastructure?

- Since ICCloud is a .net application (c#, vb.net) it favorites Microsoft Solutions
- Tables, Blobs and Queues are also supported in other infrastructures and it would be a challenge to see it happening.
- During the first face of development we will be utilizing only the MS Azure Cloud services.

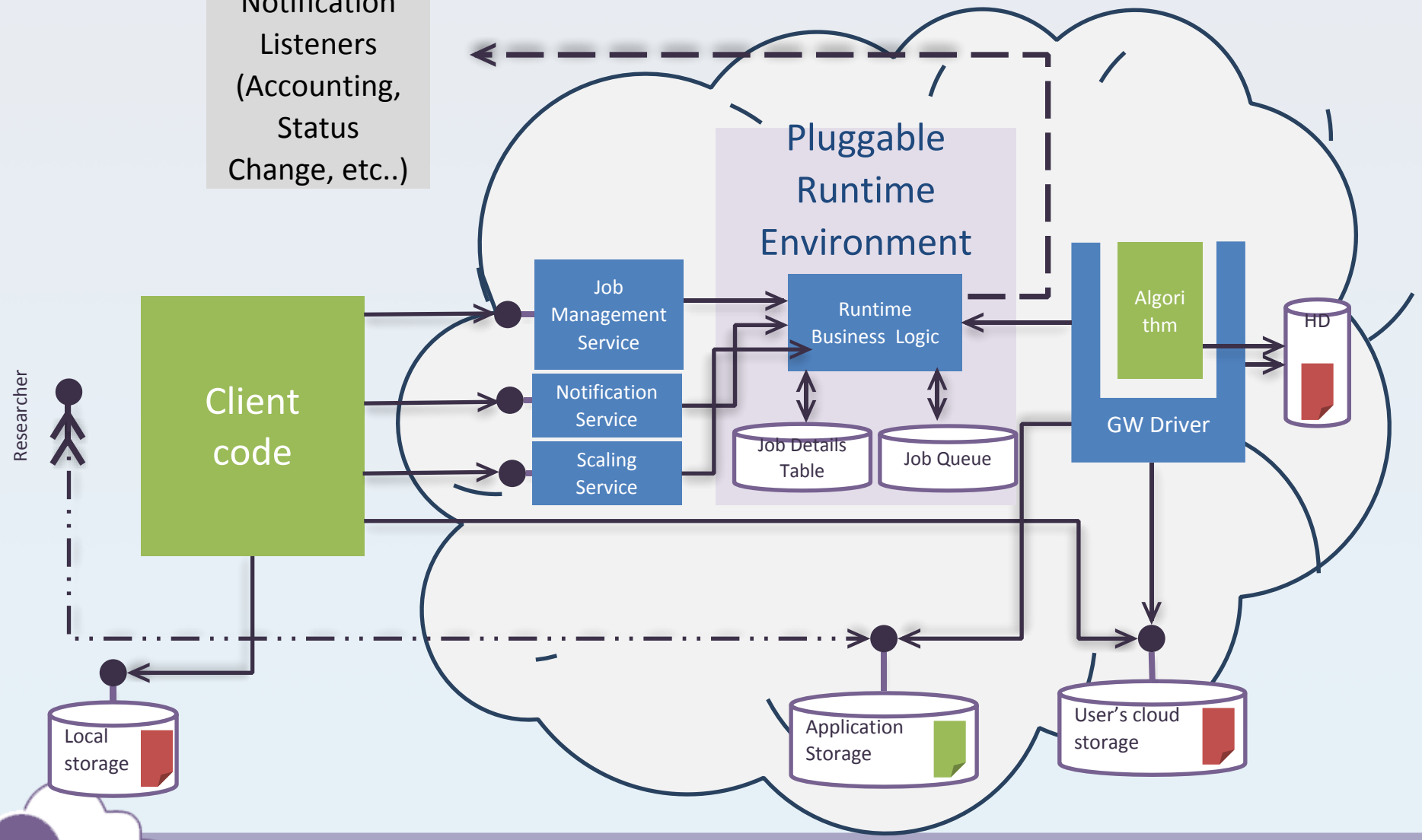
What is a Typical Scenario Venus-C scenario?

Simple Walkthrough

Application Code

VENUS-C Services & SDKs

Existing Components



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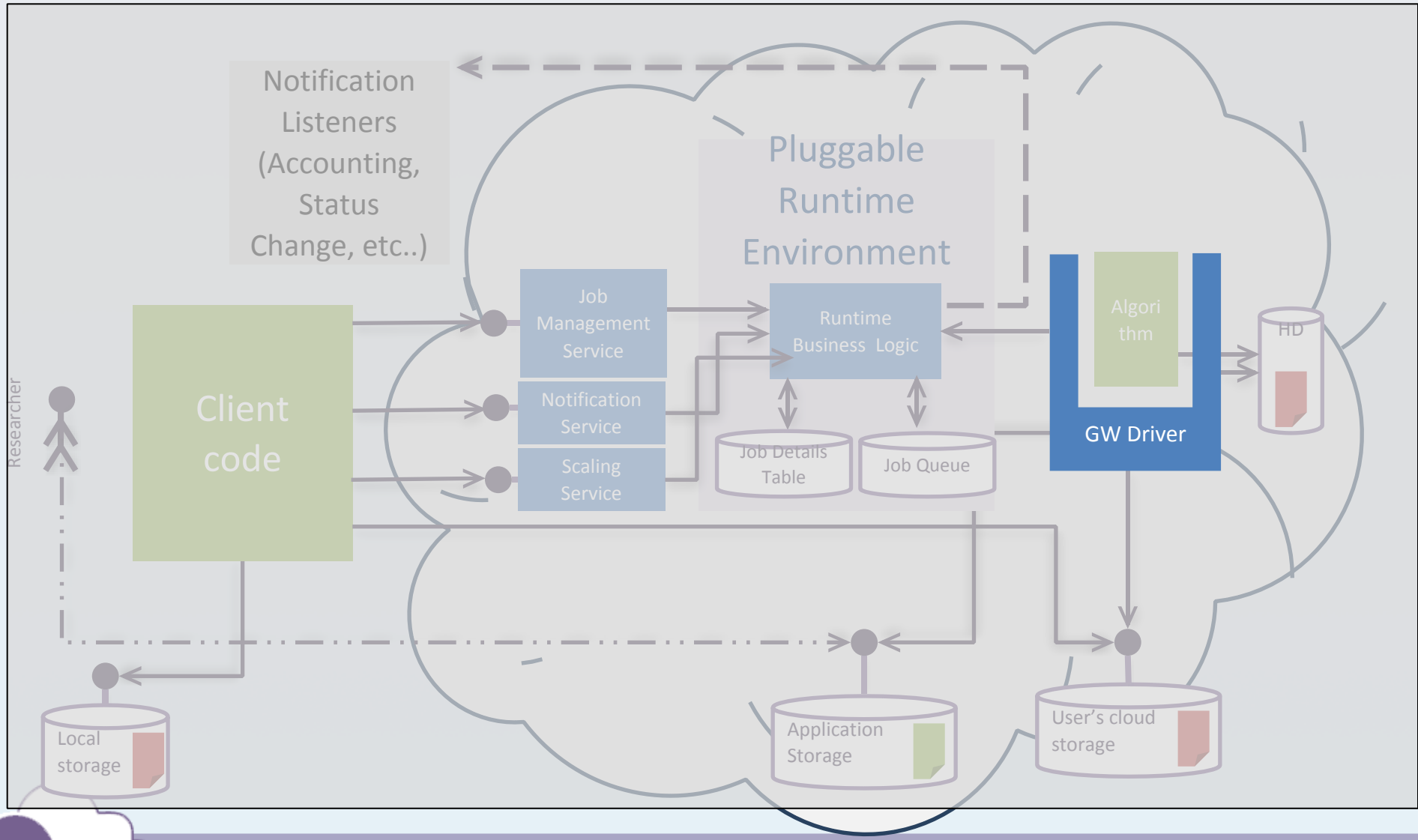
Simple Walkthrough



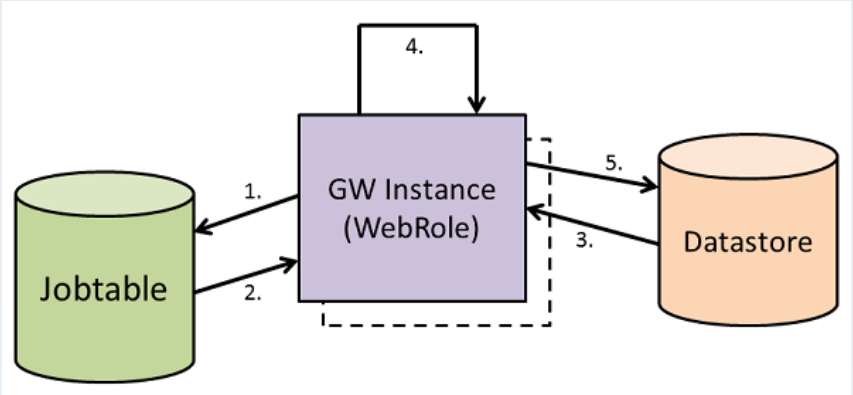
Generic Worker

•The functionality of the

Generic Worker

can be described in six easy steps.

1. Looking for submitted jobs
2. Fetching job details
3. Download application and required files
4. Run application
5. Write back result files



It can be used both for submitting jobs and data management.

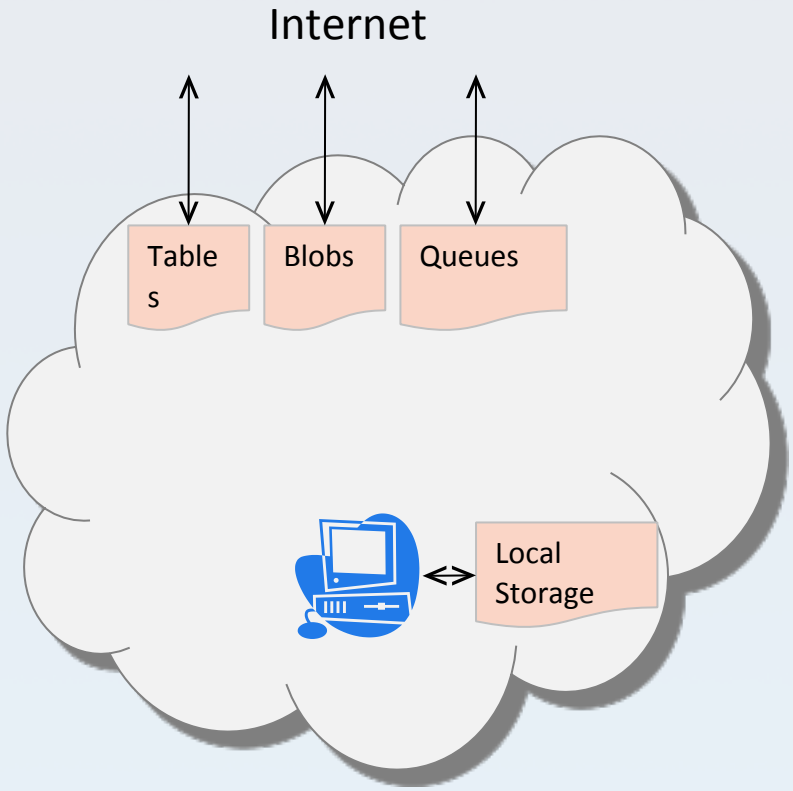
MS Azure - Computation

- **Web role**. A Windows Azure Web role is used for hosting front-end web applications behind Internet Information Services (IIS)
- **Worker role**. A Worker can run anything but is most commonly used to host background processing behind a web role. Windows Azure Web and Worker roles enable developers to deploy and manage applications services as a whole as opposed to individual Virtual Machines (VMs).
- **Virtual Machine role**. The Windows Azure Virtual Machine (VM) role enables you to deploy a custom Windows Server 2008 R2 (Enterprise or Standard) image to Windows Azure. The VM role runs a virtual hard drive (VHD) image of a Windows Server 2008 R2 virtual machine

MS Azure – Storage

All your content stored on Windows Azure is **replicated three times**

- Windows Azure gives you four core storage services that are secure, scalable and easy to access that remain persistent and durable storage in the cloud. Blobs, Tables, and Queues are all available as part of the Windows Azure Storage account, and provide durable storage on the Windows Azure platform. Unlike local storage, blobs, tables, and queues are accessible by multiple applications or application instances simultaneously, and represent dedicated storage instead of temporary.



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Cloud Storage

All your content stored on Windows Azure is **replicated three times**

- Binary Large Object (BLOB) Service, is currently the simplest way to store text or binary data with Windows Azure.
- Table Service is better for large amounts of data that need additional structure, which works exceptionally well with applications that need to work with data in a very detailed manner via queries.
- Queue Service for reliable, persistent messaging between Web and Worker role instances.

Cloud Storage – BLOB

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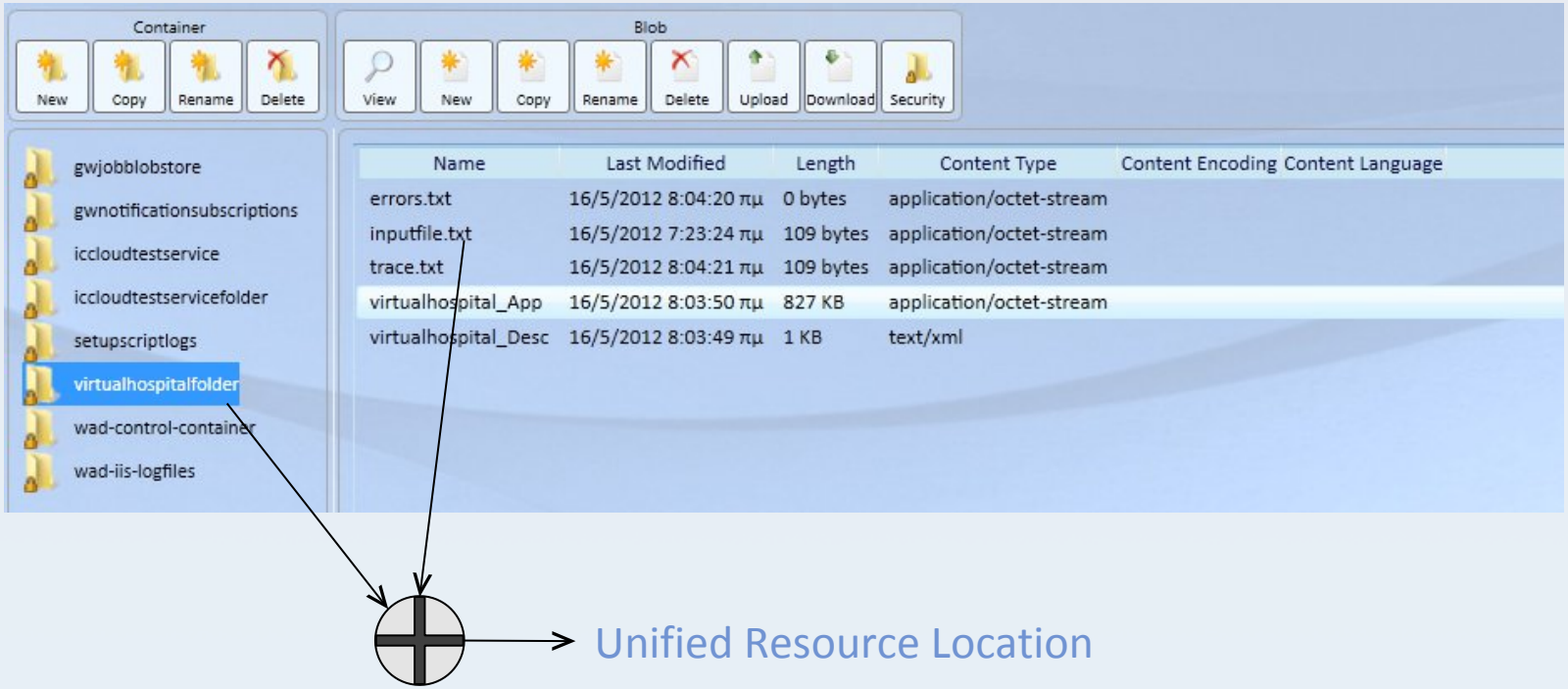
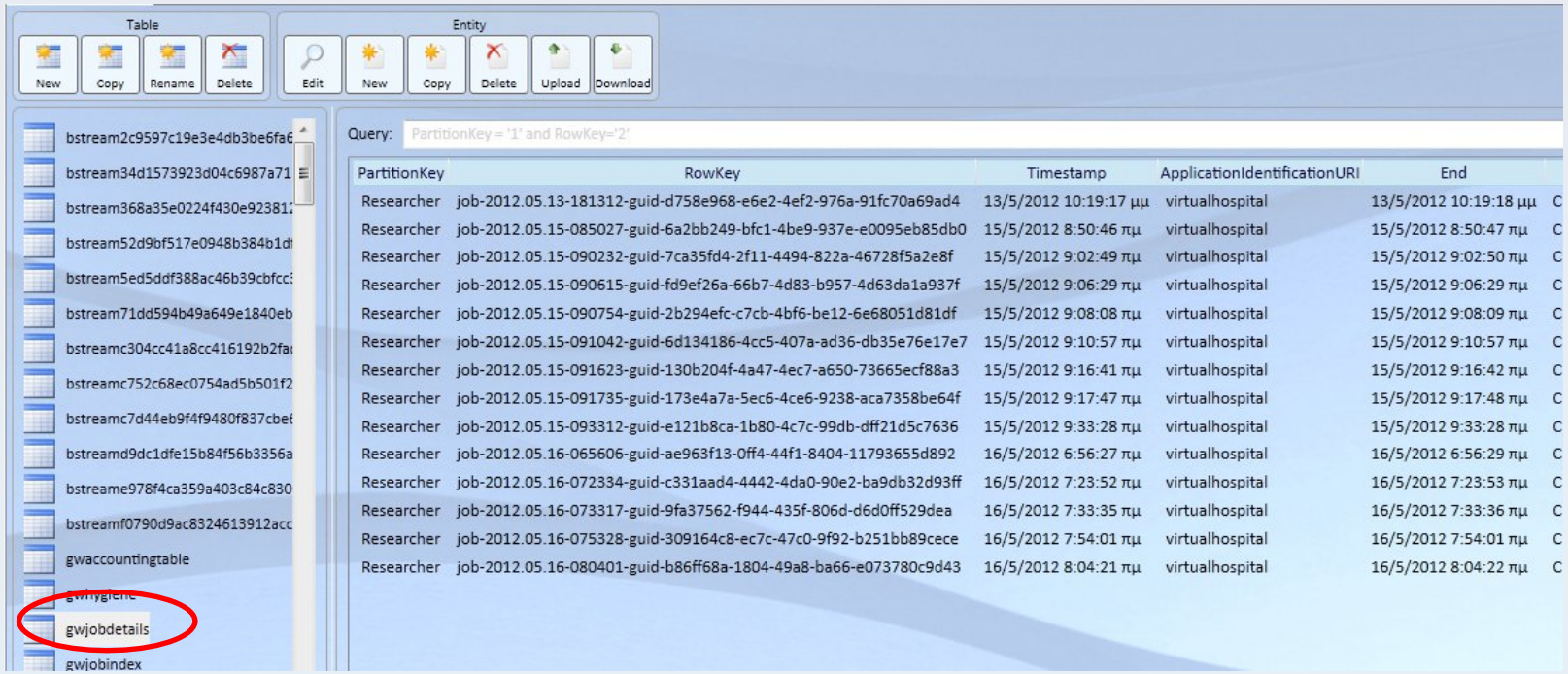


- *_App = application files and executable package
- *_Desc = application description

Cloud Storage – Tables

All your content stored on Windows Azure is **replicated three times**



- Unique name inside a storage account
- Entities contain at least a Partition and Row Key. Other columns can vary even in the same table.

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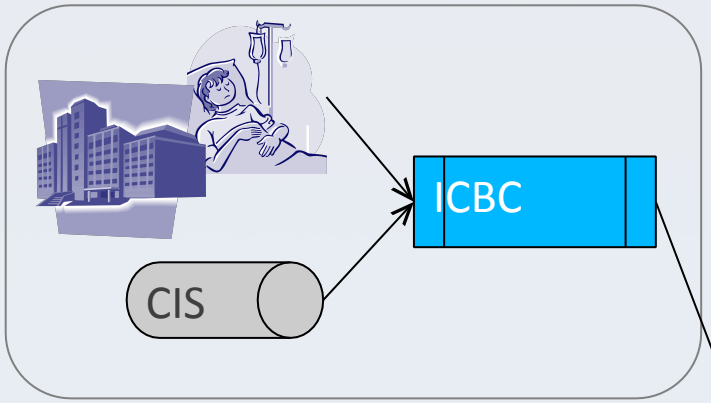
MS Azure – Virtual Network

- Windows Azure Connect. Windows Azure Connect provides a simple and easy-to-manage mechanism to setup IP-based network connectivity between on-premises and Windows Azure resources. This capability makes it easier for an organization to migrate their existing applications to the cloud by enabling direct IP-based network connectivity with their existing on-premises infrastructure. Developers can setup direct connectivity to their cloud-hosted virtual machines, enabling remote administration and troubleshooting using the same tools that they use for on-premises applications.

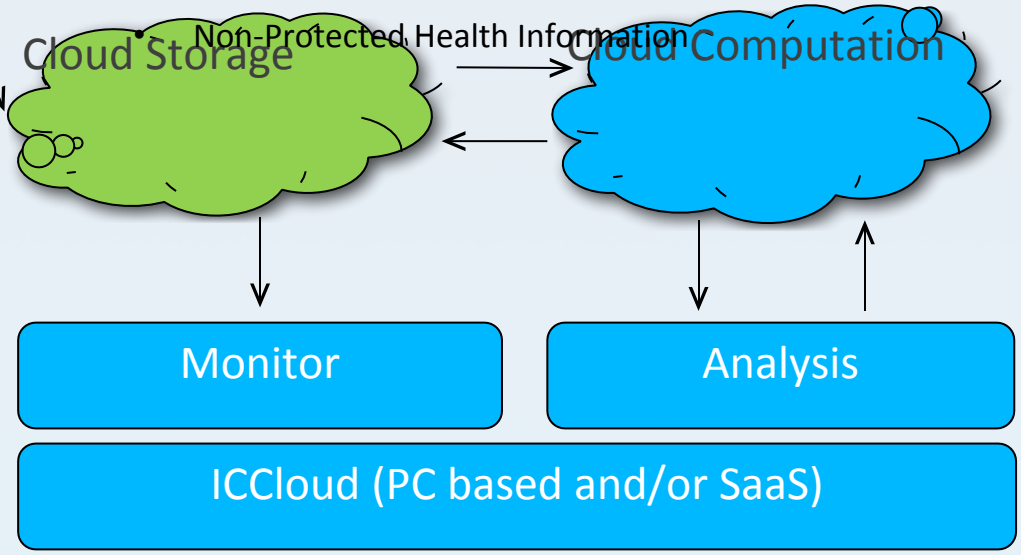
- Windows Azure Traffic Manager.
  - Windows Azure Traffic Manager is a new feature that allows customers to load balance traffic to multiple hosted services. Developers can choose from three load balancing methods: Performance, Failover, or Round Robin.
  - Traffic Manager will monitor each collection of hosted service on any http or https port. If it detects the service is offline Traffic Manager will send traffic to the next best available service. By using this new feature businesses will see increased reliability, availability and performance in their applications.

ICCloud – Main Goal



- **Upload us many patients as possible (create a database using Windows Azure Tables) on Venus-C.**
- What kind of patients?
  - Surrogate patients.
- Where the data come from?
  - Patient's vital signs are based on 12 record sets captured in real ICU setups.
- What kind of Data to upload on public Cloud?
  - Non-Protected Health Information

- Simple Use Case
  - Develop a scenario where a *Patient* is hospitalized.
  - Monitor Patient.
  - Observe and find similar behaviours among the patient database.
    - fire-up jobs based on a map reduce model.



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ICCloud – PHI

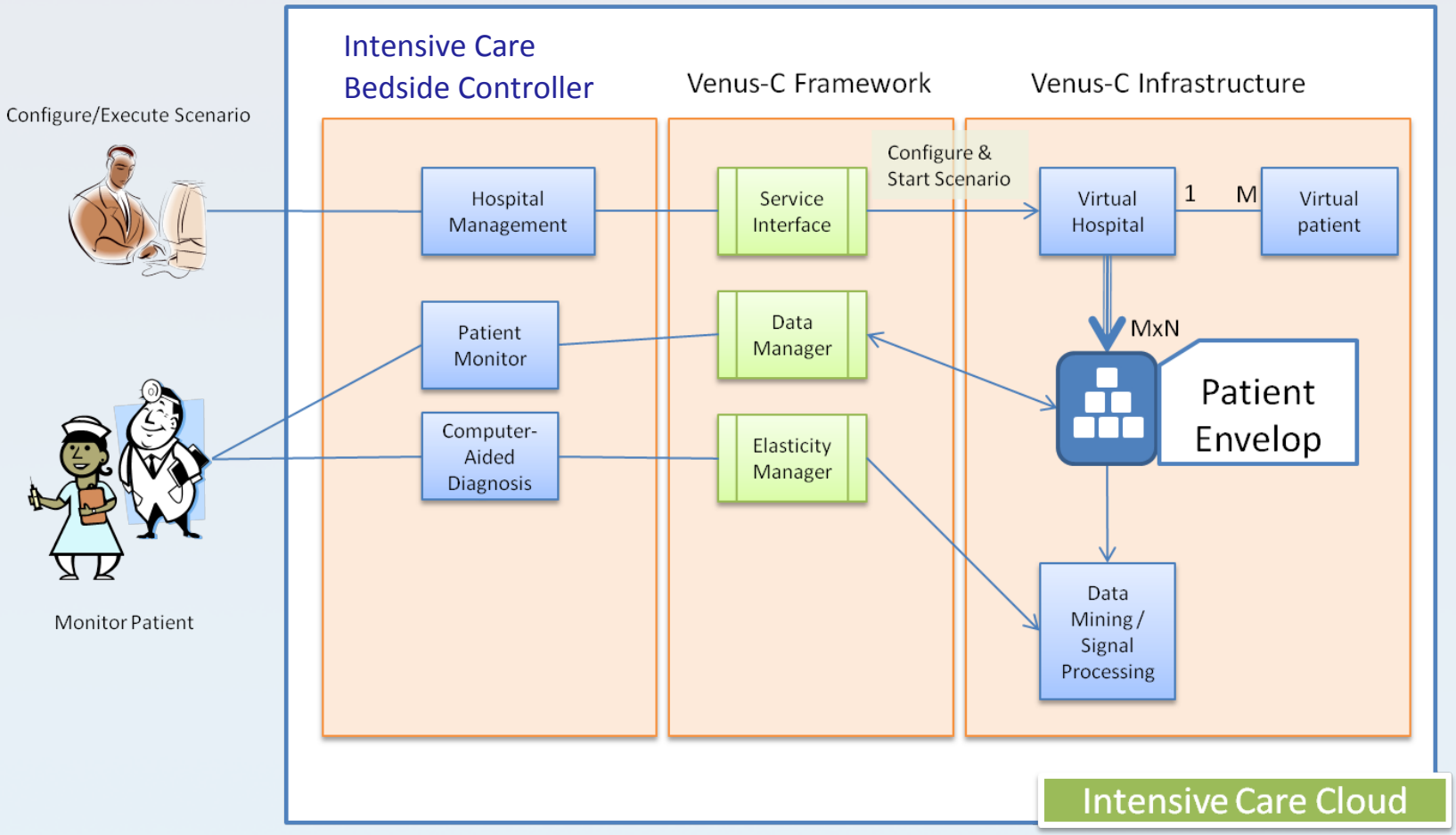
PUBLIC LAW 104-191 AUG. 21, 1996 HEALTH INSURANCE PORTABILITY AND ACCOUNTABILITY ACT OF 1996
http://aspe.hhs.gov/admnsimp/pl104191.htm

- 1. Names
- 2. All geographical identifiers smaller than a state
- 3. Dates (other than year) directly related to an individual
- 4. Phone numbers
- 5. Fax numbers
- 6. Email addresses
- 7. Social Security numbers
- 8. Medical record numbers
- 9. Health insurance beneficiary numbers
- 10. Account numbers
- 11. Certificate/license numbers
- 12. Vehicle identifiers and serial numbers, including license plate numbers;
- 13. Device identifiers and serial numbers;
- 14. Web Uniform Resource Locators (URLs)
- 15. Internet Protocol (IP) address numbers
- 16. Biometric identifiers, including finger, retinal and voice prints
- 17. Full face photographic images and any comparable images
- 18. Any other unique identifying number, characteristic, or code except the unique code assigned by the investigator to code the data

VITAL SIGNS AND PHYSIOLOGICAL PARAMETERS ARE **non**-protected health information

Thus they can be uploaded **outside** hospital premises

ICCloud - Components



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ICCloud -Components

Hospital Management. Used to create the schema of Virtual Hospitals and Patients. Configuration views will provide the tools to start and stop the simulation. The objective is to develop a stand alone application (second phase).

Patient Monitor. Download vital signs and physiological parameters from Cloud Storage.

Virtual Hospital. Hospital simulation executed in a VM using a Generic Worker (a simple job).

Virtual Patient. Patient simulation executed in a VM using a Generic Worker (a simple job).

Patient Envelop. A group of Azure Tables to store patient physiological parameters and vital signs (currently one table can serve our needs).

Computer-Aided Diagnosis. Use a parallelization technique (like MAP-REDUCE) to reduce processing time. *Using the elasticity manager and setting criticality cardinals one could scale up or down the processing power. Research Activities.*

Data Analysis (timeseries). Develop a naïve algorithm to serve in the evaluation of the proposed solution. *Research Activities*

ICCloud – Storage model Patient Data

- Vital signs, Patient non-Private Health Information

PartitionKey	RowKey	Timestamp	DValue	PhysioIDState	SValue	TimeOffset	TypeOfDouble
CONST_DURING_RATE_S	10003	25/2/2012 8:43:30 μμ	0	NORMAL	I-TIME	5438	False
CONST_DURING_RATE_S	10015	25/2/2012 8:43:30 μμ	0	NORMAL	I-TIME	5450	False
CONST_DURING_RATE_S	10040	25/2/2012 8:43:30 μμ	0	NORMAL	I-TIME	5462	False
CONST_DURING_RATE_S	10065	25/2/2012 8:43:31 μμ	0	NORMAL	I-TIME	5474	False
CONST_DURING_RATE_S	10090	25/2/2012 8:43:31 μμ	0	NORMAL	I-TIME	5486	False
CONST_DURING_RATE_S	10102	25/2/2012 8:43:32 μμ	0	NORMAL	I-TIME	5498	False
CONST_DURING_RATE_S	10127	25/2/2012 8:43:32 μμ	0	NORMAL	I-TIME	5510	False
CONST_DURING_RATE_S	10152	25/2/2012 8:43:32 μμ	0	NORMAL	I-TIME	5522	False
CONST_DURING_RATE_S	10177	25/2/2012 8:43:33 μμ	0	NORMAL	I-TIME	5534	False
CONST_DURING_RATE_S	10189	25/2/2012 8:43:33 μμ	0	NORMAL	I-TIME	5546	False
CONST_DURING_RATE_S	10214	25/2/2012 8:43:34 μμ	0	NORMAL	I-TIME	5558	False
CONST_DURING_RATE_S	10239	25/2/2012 8:43:34 μμ	0	NORMAL	I-TIME	5570	False
CONST_DURING_RATE_S	1024	25/2/2012 8:43:35 μμ	0	NORMAL	I-TIME	558	False
CONST_DURING_RATE_S	10264	25/2/2012 8:43:35 μμ	0	NORMAL	I-TIME	5582	False
CONST_DURING_RATE_S	10289	25/2/2012 8:43:35 μμ	0	NORMAL	I-TIME	5594	False
CONST_DURING_RATE_S	10301	25/2/2012 8:43:36 μμ	0	NORMAL	I-TIME	5606	False

PartitionKey	RowKey	Timestamp	DataType	Name	Usage
GLOBALREFERENCE		13/2/2012 8:53:53 πμ			
GLOBALREFERENCE	1	13/2/2012 8:53:19 πμ	Double	NOM_ECG_CARD_BEAT_RATE	MEASUREMENTS
GLOBALREFERENCE	10	13/2/2012 8:53:22 πμ	Double	NOM_PULS_RATE	MEASUREMENTS
GLOBALREFERENCE	11	13/2/2012 8:53:23 πμ	Double	NOM_EEG_FREQ_PWR_SPEC_CRTX_DOM_MEAN	MEASUREMENTS
GLOBALREFERENCE	12	13/2/2012 8:53:23 πμ	Double	NOM_EEG_PWR_SPEC_THETA_REL	MEASUREMENTS
GLOBALREFERENCE	13	13/2/2012 8:53:24 πμ	Double	NOM_AWAY_CO2_INSP_MIN	MEASUREMENTS
GLOBALREFERENCE	14	13/2/2012 8:53:24 πμ	Double	NOM_PRESS_BLD_VEN_CENT_MEAN	MEASUREMENTS
GLOBALREFERENCE	15	13/2/2012 8:53:24 πμ	Double	NOM_AWAY_CO2_ET	MEASUREMENTS
GLOBALREFERENCE	16	13/2/2012 8:53:25 πμ	Double	HIGH_CIRC_PRESSURE_LIM_CM	MEASUREMENTS
GLOBALREFERENCE	17	13/2/2012 8:53:25 πμ	Double	NOM_ECG_V_P_C_CNT	MEASUREMENTS
GLOBALREFERENCE	18	13/2/2012 8:53:26 πμ	Double	NOM_AWAY_RESP_RATE	MEASUREMENTS
GLOBALREFERENCE	19	13/2/2012 8:53:26 πμ	Double	NOM_ECG_AMPL_ST_II	MEASUREMENTS
GLOBALREFERENCE	2	13/2/2012 8:53:19 πμ	Double	NOM_ECG_AMPL_ST_AVF	MEASUREMENTS
GLOBALREFERENCE	20	13/2/2012 8:53:26 πμ	Double	NOM_EEG_PWR_SPEC_TOT	MEASUREMENTS
GLOBALREFERENCE	21	13/2/2012 8:53:27 πμ	Double	NOM_PLETH_PULS_RATE	MEASUREMENTS
GLOBALREFERENCE	22	13/2/2012 8:53:27 πμ	Double	LOW_EXHALED_TIDAL_VOL_LIM_L	MEASUREMENTS
GLOBALREFERENCE	23	13/2/2012 8:53:28 πμ	Double	APNEA_INTERVAL_SECS	MEASUREMENTS
GLOBALREFERENCE	24	13/2/2012 8:53:28 πμ	Double	VENT_SET_BASE_FLOW_L_MIN	MEASUREMENTS
GLOBALREFERENCE	25	13/2/2012 8:53:28 πμ	Double	NOM_EEG_BISPECTRAL_INDEX	MEASUREMENTS
GLOBALREFERENCE	26	13/2/2012 8:53:29 πμ	Double	NOM_EEG_BIS_SIG_QUAL_INDEX	MEASUREMENTS
GLOBALREFERENCE	27	13/2/2012 8:53:29 πμ	Double	NOM_ECG_AMPL_ST_AVR	MEASUREMENTS
GLOBALREFERENCE	28	13/2/2012 8:53:30 πμ	Double	NOM_EEG_RATIO_SUPPRN	MEASUREMENTS

Check In DateTime

ICCloud – Storage model
Patient List

Patient List

PartitionKey	RowKey	Timestamp	BaseStreamID	Gender	Height	InICU	Weight	YearOfBirth
GLOBALREFERENCE	000fd4ea-1a70-421f-9be4-e8de02677abf	8/3/2012 12:31:23 μμ	2c9597c1-9e3e-4db3-be6f-a6fe6b693ca4	MALE	159	False	63	1942
GLOBALREFERENCE	00fc4919-4cb6-4ae4-a255-20be99c2e7fc	8/3/2012 12:31:23 μμ	c304cc41-a8cc-4161-92b2-fad3cdd68e28	MALE	175	False	96	1970
GLOBALREFERENCE	0109d681-3eb6-432f-ae81-b1b889409dc3	8/3/2012 12:31:23 μμ	34d15739-23d0-4c69-87a7-112c5e3a53e1	FEMALE	160	False	75	1934
GLOBALREFERENCE	01318657-cb25-4339-80be-4d6715df3fff	13/5/2012 7:14:04 πμ	c304cc41-a8cc-4161-92b2-fad3cdd68e28	MALE	170	True	70	1970
GLOBALREFERENCE	027b7bb6-2a35-40a5-aa1a-484999f5ca99	8/3/2012 12:31:23 μμ	2c9597c1-9e3e-4db3-be6f-a6fe6b693ca4	MALE	161	False	67	1942
GLOBALREFERENCE	02ebeff9-ba28-48a2-8971-af3aa07a3349	8/3/2012 12:31:23 μμ	c7d44eb9-f4f9-480f-837c-be60720a1ae8	MALE	170	False	70	1992
GLOBALREFERENCE	031be48f-45b9-4581-9094-c9938d3ea077	8/3/2012 12:31:23 μμ	34d15739-23d0-4c69-87a7-112c5e3a53e1	FEMALE	160	False	76	1934
GLOBALREFERENCE	03dffb59-d9c7-4074-aac6-8f4113d6530f	8/3/2012 12:31:23 μμ	e978f4ca-359a-403c-84c8-302c50a7266d	MALE	185	False	97	1975
GLOBALREFERENCE	0403adbd-bf34-47d4-b7b7-96766d5707ae	8/3/2012 12:31:23 μμ	34d15739-23d0-4c69-87a7-112c5e3a53e1	FEMALE	159	False	63	1934
GLOBALREFERENCE	04114440-4946-4134-af5a-4d49730cf81b	8/3/2012 12:31:23 μμ	71dd594b-49a6-49e1-840e-bc99f7c1c3b0	MALE	180	False	94	1937
GLOBALREFERENCE	044af177-1e60-43d5-97ae-2ecf8e9b580c	8/3/2012 12:31:23 μμ	2c9597c1-9e3e-4db3-be6f-a6fe6b693ca4	MALE	160	False	65	1942
GLOBALREFERENCE	046dcd5e-3e30-4c3c-a965-163ae7697a05	8/3/2012 12:31:23 μμ	34d15739-23d0-4c69-87a7-112c5e3a53e1	FEMALE	160	False	65	1934
GLOBALREFERENCE	048442cb-f120-4787-b96e-316464bee155	8/3/2012 12:31:23 μμ	2c9597c1-9e3e-4db3-be6f-a6fe6b693ca4	MALE	161	False	67	1942

Additional Info

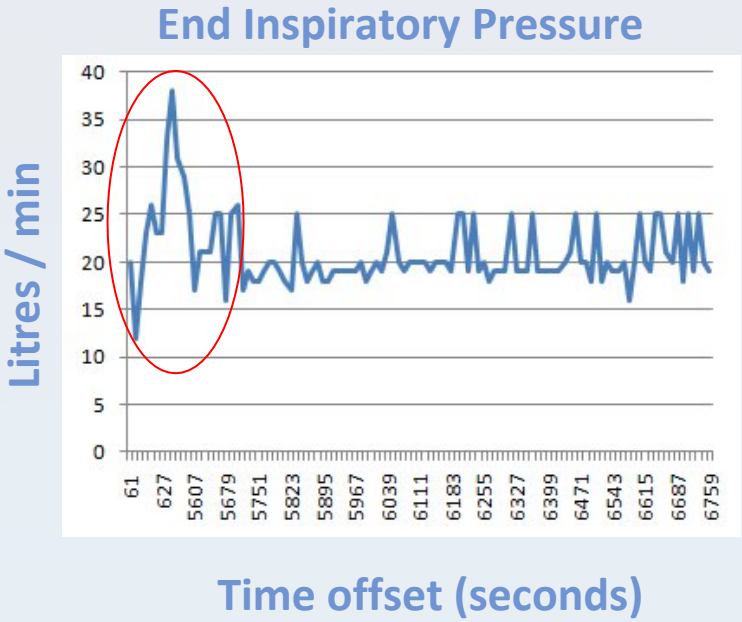
- Hospital Info
- Doctor
- …

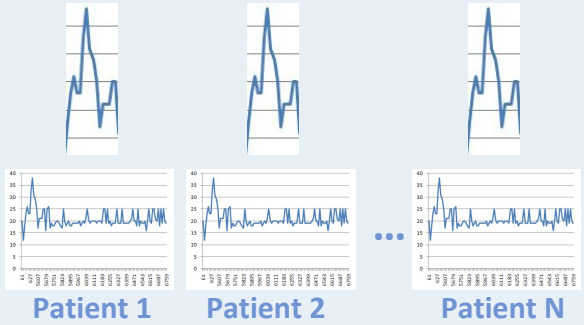
Real Stream Information

PartitionKey	RowKey	Timestamp	DateOfBirth	Gender	Height	Weight	Cause	Outcome
GLOBALREFERENCE	2c9597c1-9e3e-4db3-be6f-a6fe6b693ca4	6/3/2012 5:07:43 μμ	7/1/1942 12:00:00 πμ	MALE	180	94	CARDIOGENIC SHOCK	
GLOBALREFERENCE	34d15739-23d0-4c69-87a7-112c5e3a53e1	6/3/2012 5:08:14 μμ	22/3/1961 12:00:00 πμ	FEMALE	160	65	CARDIAC ARREST	
GLOBALREFERENCE	368a35e0-224f-430e-9238-12b9d9b976b6	6/3/2012 5:08:37 μμ	10/1/1935 12:00:00 πμ	MALE	170	65	CORONARY ARTERY BYPASS GRAFT	
GLOBALREFERENCE	4ea3eafb-bb84-4f38-8308-120e0f4b593a	6/3/2012 5:08:55 μμ	20/2/1937 12:00:00 πμ	MALE	175	100	CARDIAC ARREST	
GLOBALREFERENCE	52d9bf51-7e09-48b3-84b1-dfa7e9f8af01	6/3/2012 5:09:15 μμ	27/11/1925 12:00:00 πμ	MALE	185	84	ACUTE ABDOMEN	
GLOBALREFERENCE	5ed5ddf3-88ac-46b3-9cbf-cc38d13bb838	6/3/2012 5:09:38 μμ	3/3/1962 12:00:00 πμ	MALE	160	58	RESPIRATORY FAILURE -NEUROMYOPATHE	
GLOBALREFERENCE	71dd594b-49a6-49e1-840e-bc99f7c1c3b0	6/3/2012 5:10:01 μμ	10/9/1937 12:00:00 πμ	MALE	175	96	CORONARY ARTERY BYPASS GRAFT	
GLOBALREFERENCE	c304cc41-a8cc-4161-92b2-fad3cdd68e28	6/3/2012 5:10:13 μμ	1/1/1970 12:00:00 πμ	MALE	170	70	BRAIN INJURY	
GLOBALREFERENCE	c752c68e-c075-4ad5-b501-f2c98286ac37	6/3/2012 5:10:30 μμ	14/5/1934 12:00:00 πμ	FEMALE	160	75	CORONARY ARTERY BYPASS GRAFT	
GLOBALREFERENCE	c7d44eb9-f4f9-480f-837c-be60720a1ae8	6/3/2012 5:10:51 μμ	1/1/1992 12:00:00 πμ	MALE	165	70	MULTI-INJURY / SPLENECTOMY	
GLOBALREFERENCE	d9dc1dfe-15b8-4f56-b335-6a02fd468574	6/3/2012 5:11:04 μμ	17/12/1930 12:00:00 πμ	MALE	170	88	PELVIC ABSCESS	
GLOBALREFERENCE	e978f4ca-359a-403c-84c8-302c50a7266d	6/3/2012 5:11:18 μμ	1/1/1975 12:00:00 πμ	MALE	185	97	MULTI-INJURY	

ICCloud – Computation model

- Select a vital sign type or group of vital signs and a time period.
- Deploy jobs using generic worker. Each job fetches data from WAT and
- Use Azure Tables to synchronize jobs

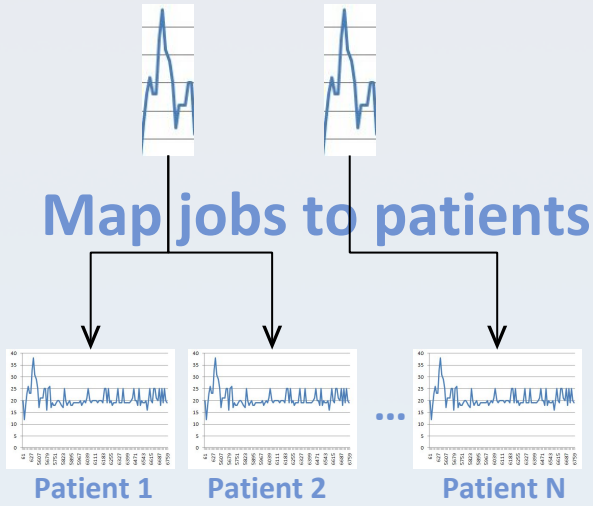




Write report

ICCloud – Computation model

- Use global storage to map jobs to patient list.
- Each job processes data until patient list is exhausted.
- Results are stored in separate table (matching method and score varies based on selected algorithm)
- Report completion
- How many jobs???
- What is the flexibility of the system in cases where massive computation is needed exceeding predefined VMs?



Find Match

Report Results

Use results for Diagnosis

How much does it cost to use the resources?

- For the first two years is free.

Storage

Storage Commitment	Price	Discount off Standard Rate
1 - 50 TB / month	$0.11 / GB	10.7%
51 - 500 TB / month	$0.096 / GB	20%
501 - 1,000 TB / month	$0.093 / GB	26.4%
1,001 TB - 5 PB / month	$0.083 / GB	29.3%
Greater than 5 PB / month	Please contact us	Please contact us

- Partition(16 bytes)+ Row(8 bytes)+TS(4 bytes)+ Dvalue (4 bytes) + PhysioState(8 bytes)+Svalue(16 bytes)+ Toffset(4 bytes)+ TypeofDouble (1 byte) = 61 Bytes per row
- 20~25 monitoring parameters
- 5 snapshots per minute => ~1MByte/per day per patient
- An average ICU 700~1000 per year

- Or
- For the first year the cost is 470 USD to store all physiological parameters.
- And 1000 Euros the cost for the Transactions (upload data 0,01 USD / 10000 transactions)
- What about vital signs
  - ECG ? => 1 Gbyte / day (512 Hz 5 lead)
  - EEG ? => 3GByte / day (200 Hz sampling rate 25 electrodes)

How much does it cost to use the resources?

Computation (Brute force)

Virtual Machine Size	CPU Cores	Memory	Cost Per Hour
Extra Small	Shared	768 MB	$0.02
Small	1	1.75 GB	$0.12
Medium	2	3.5 GB	$0.24
Large	4	7 GB	$0.48
Extra Large	8	14 GB	$0.96

- 1 Small VM processing hour costs 1 hour.

- => An average physiological parameter set consists of 20000 values. Using small VMs processing takes aprox. Less than 10 seconds for each parameter (load data from table and process).
- We monitor at least 25 parameters
- Current database consists of 500 patients thus will need 25*500 = ~30 hours

⇒4 USD per analysis (not so expensive).

⇒Using 15 small VMs (allocation for the needs of our Pilot) we could get the results in less than 2 hours.

⇒Using more VMs and selecting more effective algorithms we could achieve “Near real time diagnosis”

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ICCloud: What next?

- Upload real data in real time
  - If we overcome law issues, ICBC (bedside controller) could upload non-PHI on Cloud Storage in real time.
- Join forces with other efforts
  - MIMIC II database from MIT
- Develop the security model
  - Who is Who
  - What data can get access to
  - What access rights users have (view, write, modify, execute, …)
- Use a programming schema that no preconfigured analysis method will be needed.
  - Users should only be asked to select or provide the data analysis method
- Evaluate Venus-C elasticity manager
  - This could save time and money

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ICCLOUD

Thank you

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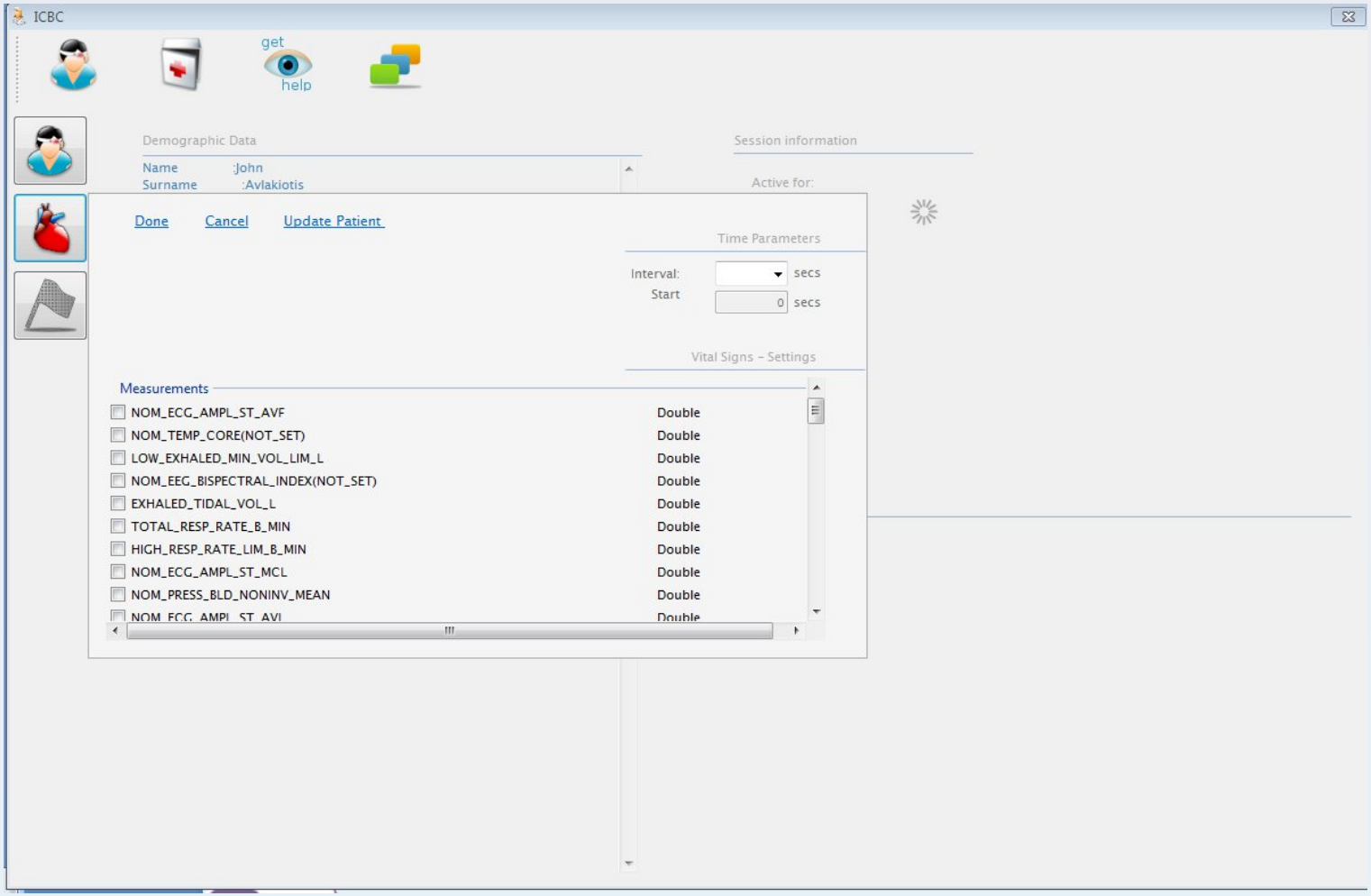
ICCloud: Select physiological parameters to monitor



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ICCloud: Monitor Patient state