OddCI: On-Demand Distributed Computing Infrastructure

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Agenda

- Motivation
- DCI requirements for MTC
- OddCI: a novel approach to DCI
- OddCI over a digital TV network
- Performance assessment
- Concluding remarks

Introduction

- MTC speeds up execution of applications, but...
  - Large amount of parallelism can only be achieved if there is a relatively high level of independency among the sub-tasks
  - The scheduler need to have access to a huge number of processors.
- In this paper we are concerned with the issue of
  - Providing ways to assemble large pools of processors for the execution of MTC applications.
  - **In particular, we focus on large-scale distributed computing infrastructures (DCI)**

System Requirements

- The throughput achieved by MTC over a DCI depends on the scale it allows
- To provide extremely high-throughput computing to a large number of applications, a DCI must meet some requirements:
  - *extremely high scalability:* it must be able to handle up to hundreds of millions of processing resources in the same way that it handles a few dozens of them;
  - *on-demand instantiation:* it must offer mechanisms for discovery, assemblage and coordination of the required resources, on demand and for a specified amount of time;
  - *efficient setup:* the configuration of the processing nodes must be carried out quickly and demanding minimal interventions.

Available Alternatives

- Desktop Grid Computing
  - the combination of computer resources from a single or multiple administrative domains applied to a common task
  - e.g. Condor, OurGrid, Alchemi
- Voluntary Computing
  - a type of distributed computing in which computer owners donate their computing resources (such as processing power and storage) to one or more "projects“.
  - e.g. SETI@home, FightAIDS@home, Folding@Home
- Infrastructure as a Service (IaaS)
  - the delivery of computer infrastructure (typically a platform virtualization environment) as a service
  - e.g. Amazon Elastic Compute Cloud (Amazon EC2),

Available Alternatives Vs Requirements

➔ No available technology is able to simultaneously address all the requirements to provide extremely high-throughput computing to over a DCI

Requirement	Available Technologies		
	Voluntary Computing	***Desktop Grid***	***Infrastructure as a Service***
Extremely High Scalability	✓	✗	✗
Efficient Setup	✗	✗	✓
On-demand Instantiation	✗	✓	✓

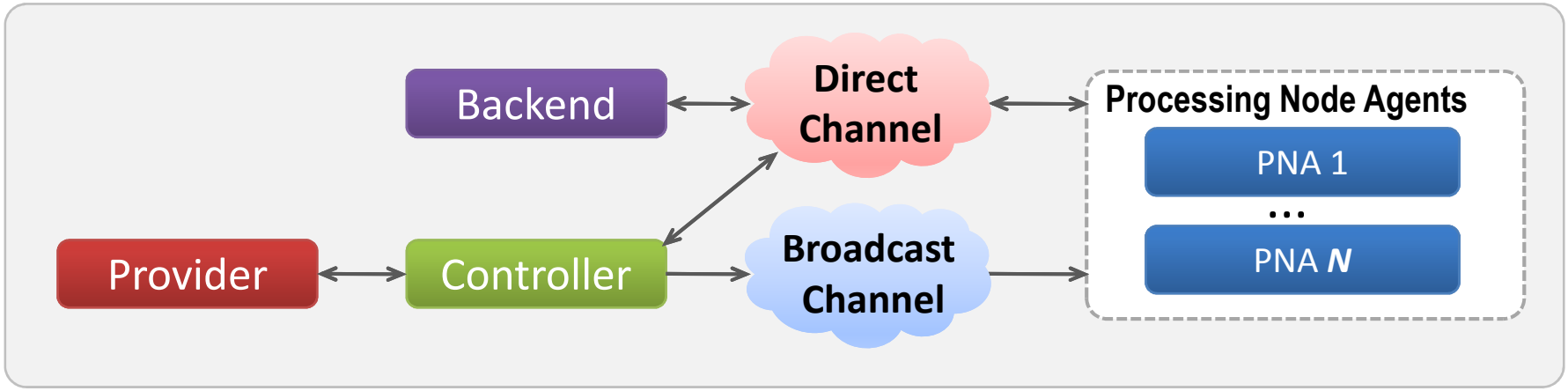
On-Demand Distributed Computing Infrastructure

- OddCI consider a special category of devices which may be organized as a broadcast network
  - Mobile phones, Digital TV receivers, Cable TV receivers
  - Devices connected to the Internet with reasonably powerful processors
  - Broadcast network can access simultaneously all the devices which can be coordinated to run some task

On-Demand Distributed Computing Infrastructure

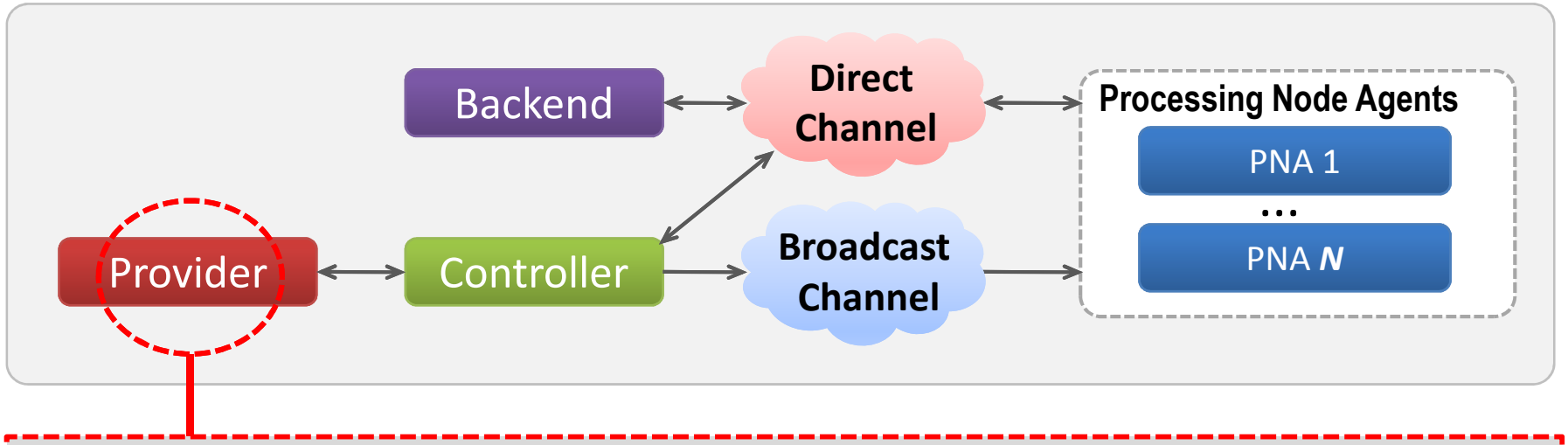
- A novel architecture for generic DCI
- Flexible
  - Can be used for several scenarios and with different technologies and devices
- Potentially highly scalable
  - Millions of potential devices
- On-demand instantiation
  - Resources are discovered and allocated as required and for a specified amount of time
- Efficient setup
  - Building DCI instances with millions or thousand nodes demands similar effort via broadcast communication

OddCI Architecture



- Provider: creates, manages, destroys OddCI instances
- Controller: Setup, controls, sends software images, monitors PNA status
- Backend: schedules tasks, provide input data, collects output data, post-processing
- PN Agent: actually runs tasks, processes control messages

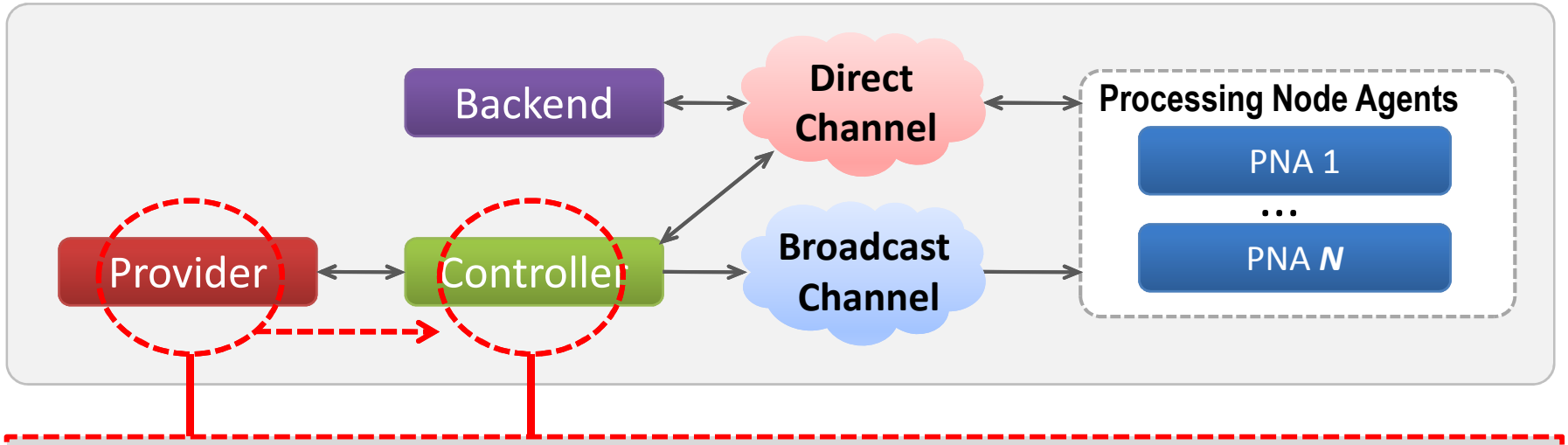
OddCI Architecture: operation



➔ User submits a "processing request" to the **provider**

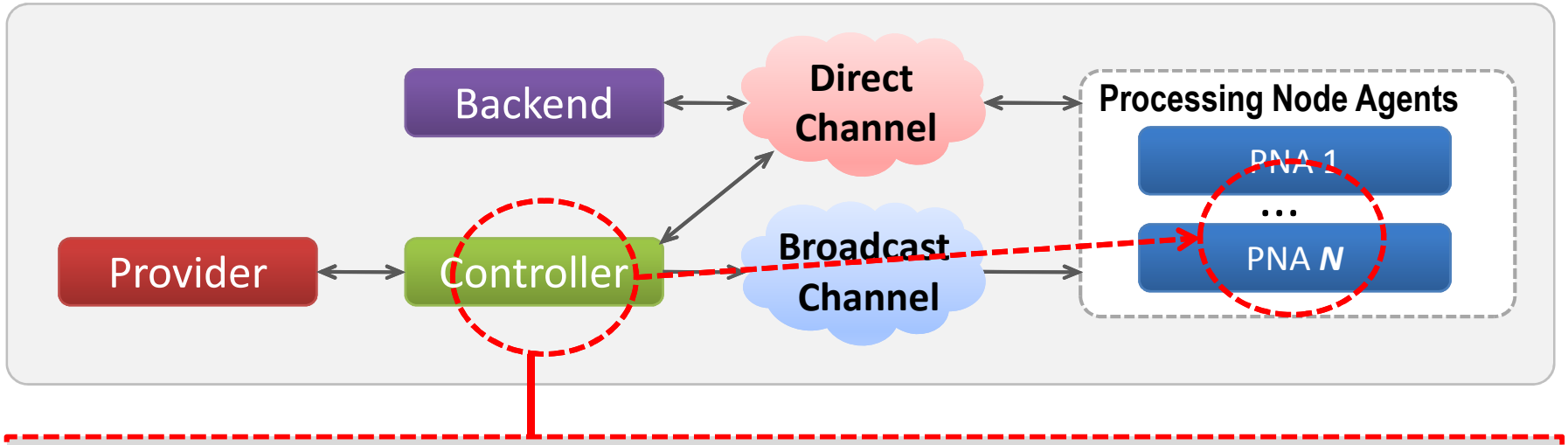
- DCI instance size (number of processing nodes)
- Application image, common data
- Node requirements

OddCI Architecture: operation



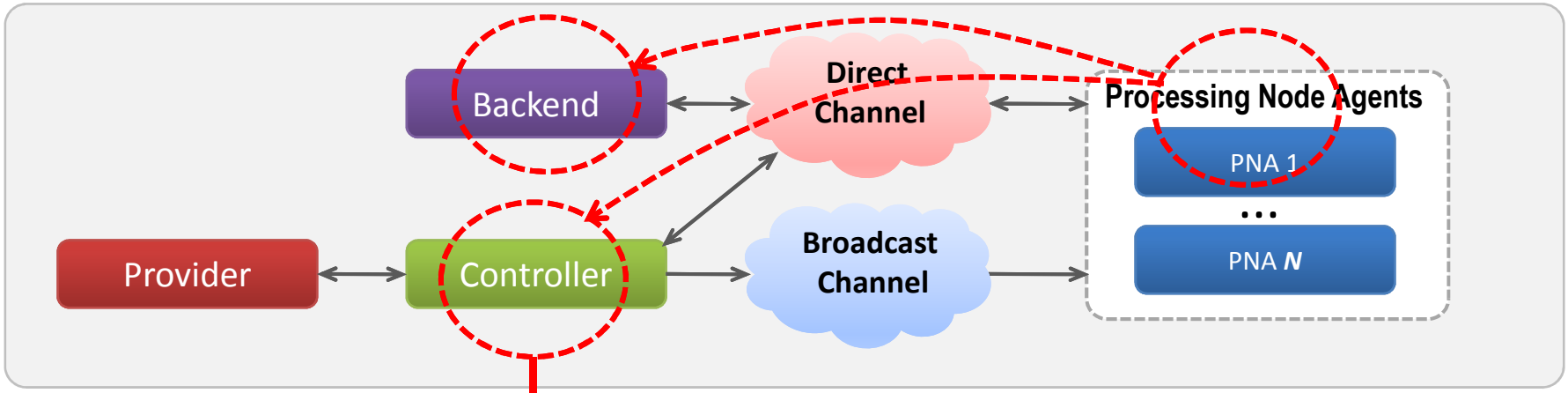
- **Provider** evaluate the user request
  - checks availability
  - keeps control information
- Command the **Controller** for creating the OddCI required instance

OddCI Architecture: operation



- **Controller** triggers a wakeup process to ***PNAs*** through the broadcast channel
  - PNA can drop jobs when busy or accept when idle
- **Controller** also send other control messages (e.g. dismantle instances)
- All **PNA** receives messages simultaneously

OddCI Architecture: operation

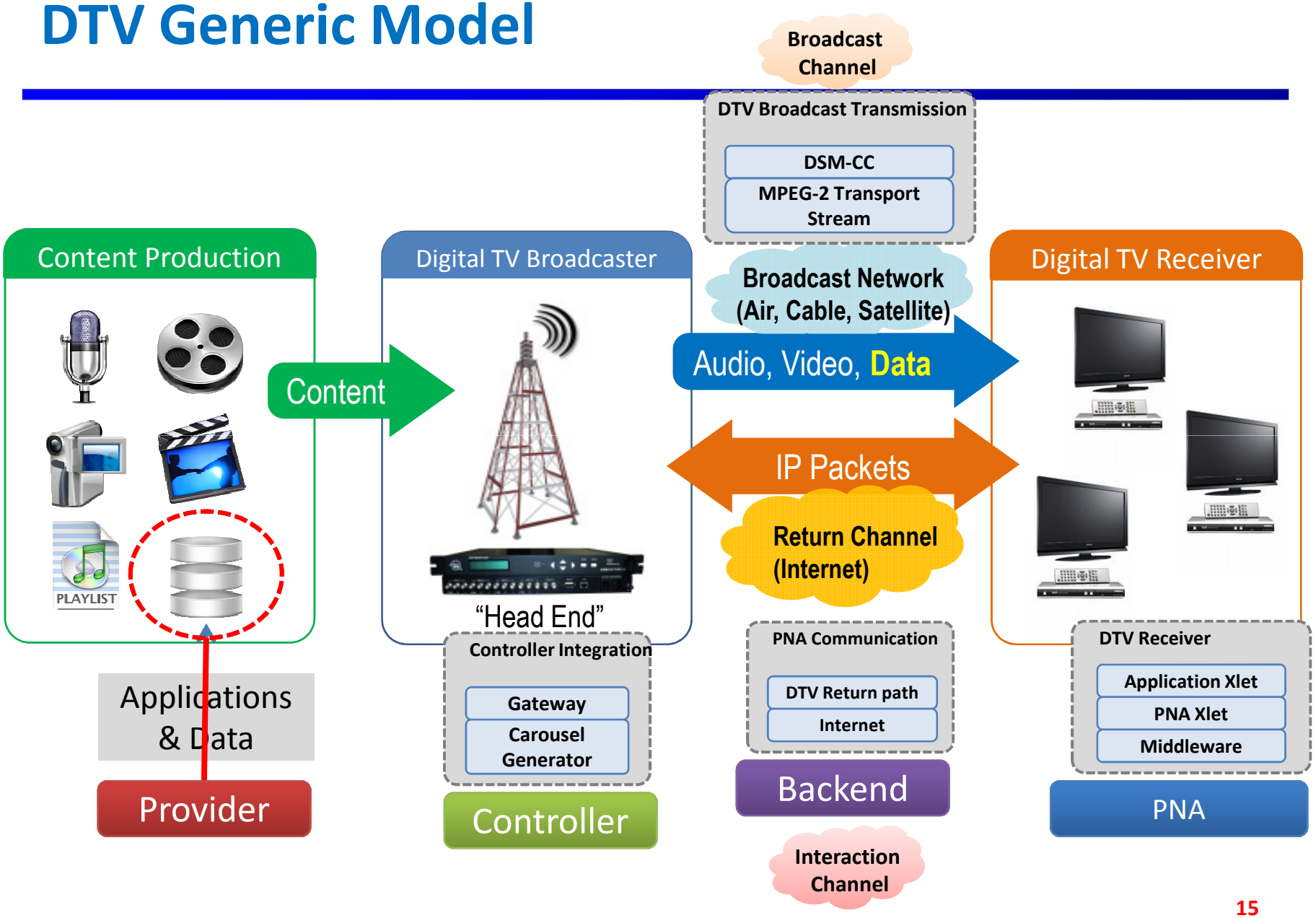


- **PNA** loads application image for execution in a DVE (Dynamic Virtual Environment)
- **Controller** monitors active **PNA**
- **Direct channel** is a two-way road
  - **Application** can interact with the **Backend** for requesting specific input data or send results (optional)
  - **PNA** sends status messages frequently to the **Controller**

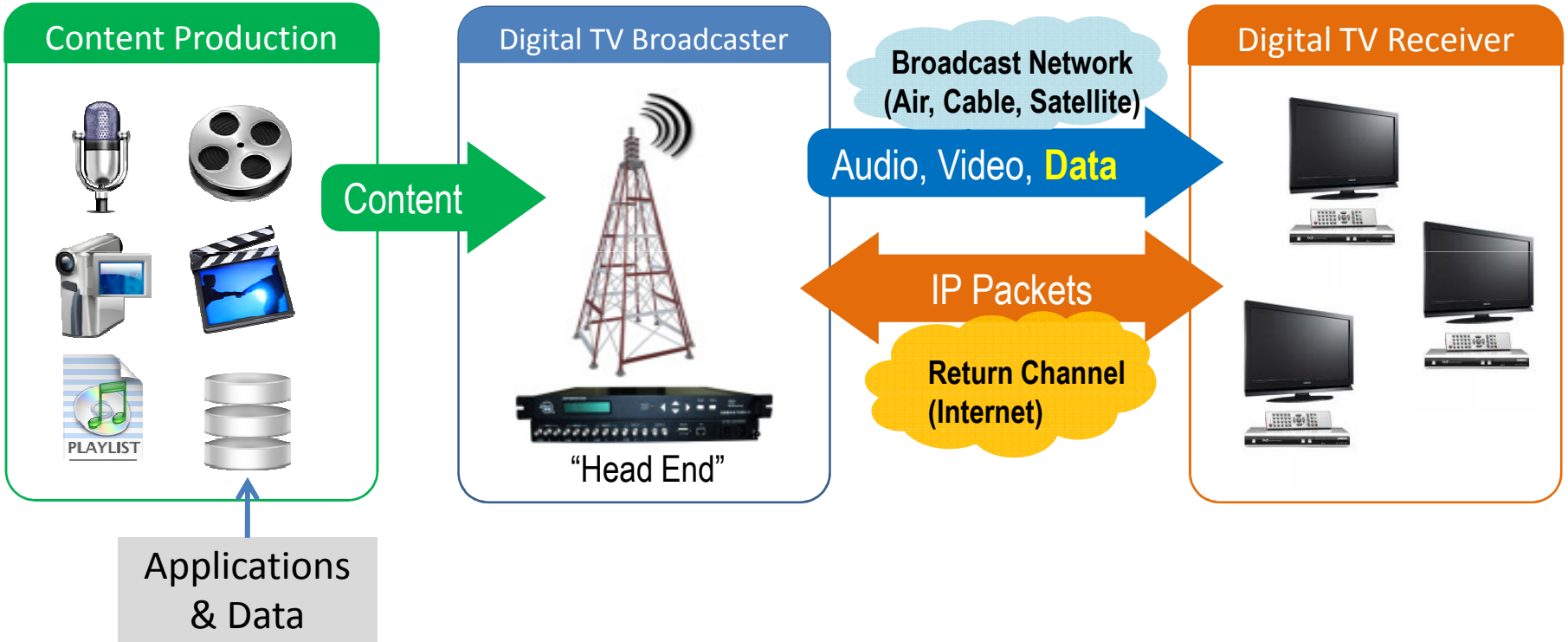
Proof of Concept: OddCI over a Digital TV Network

- Why DTV network?
  - Open technology, well-defined standards
  - Native transmission of data in broadcast
  - Fast expansion, being deployed in many countries
  - Great spectrum of devices: from set-top boxes to mobile devices
  - Potential for millions of devices
  - Powerful middleware
- And also ...
  - Feasibility for building a testbed
  - Previous experience of our group

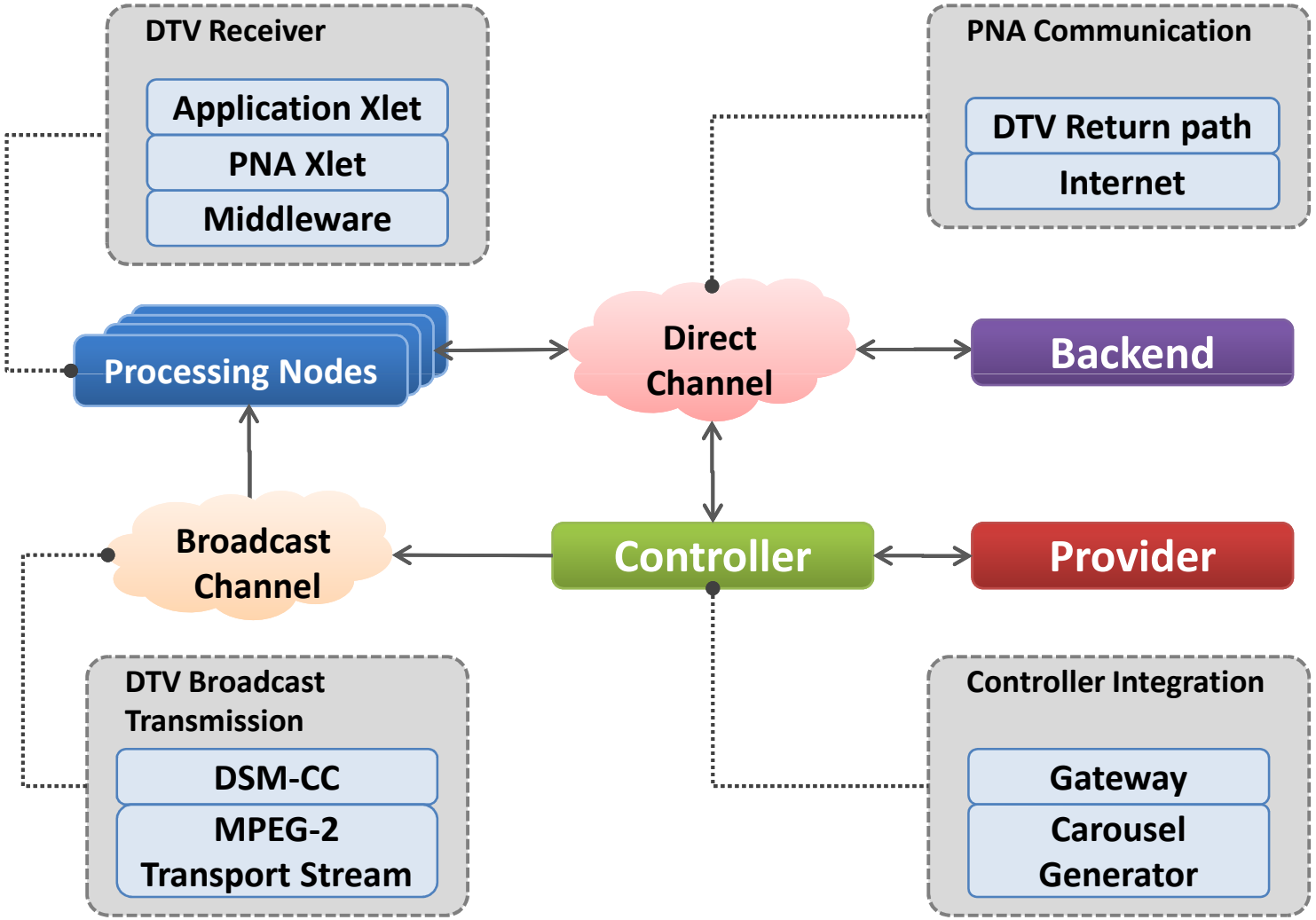
DTV Generic Model



DTV Generic Model



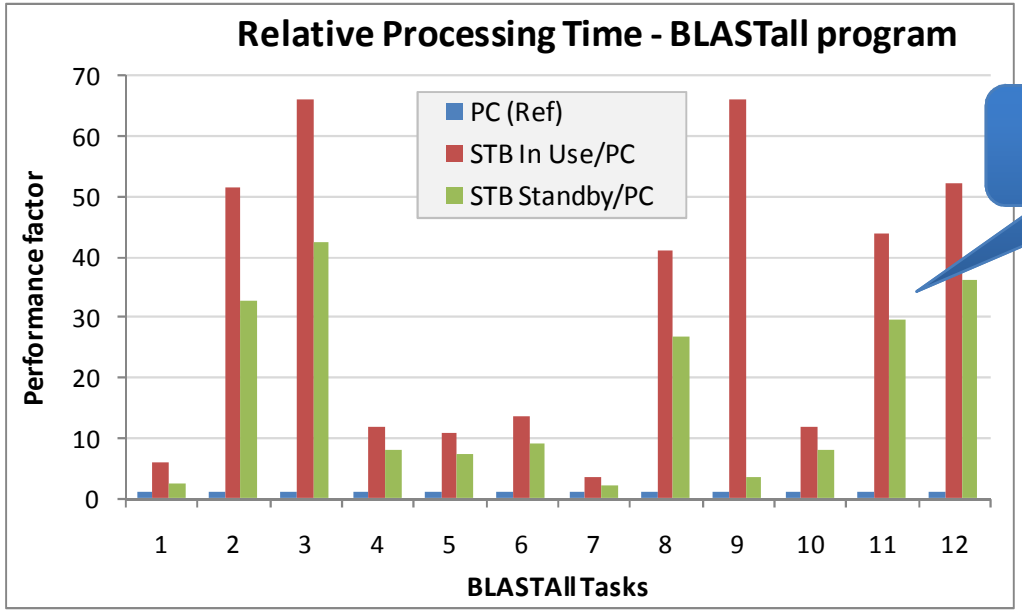
Implementing OddCI over DTV components



Experiment setup

- Experiments were performed using:
  - SBTVD (Brazilian DTV standard)
  - Software
    - Brazilian middleware “Ginga” implementation from UFPB
    - NCBI Toolkit ported using a cross-compiler
    - BLAST – Basic Local Alignment Search Tool tasks, from NCBI
  - DTV Receiver
    - STI microelectronic´s processor ST7109
    - 32MB Flash memory, 256MB RAM
  - Reference system
    - Dual Core Pentium, 1.6GHz, 1GB RAM, Debian Linux

DTV STB Performance - Preliminary findings

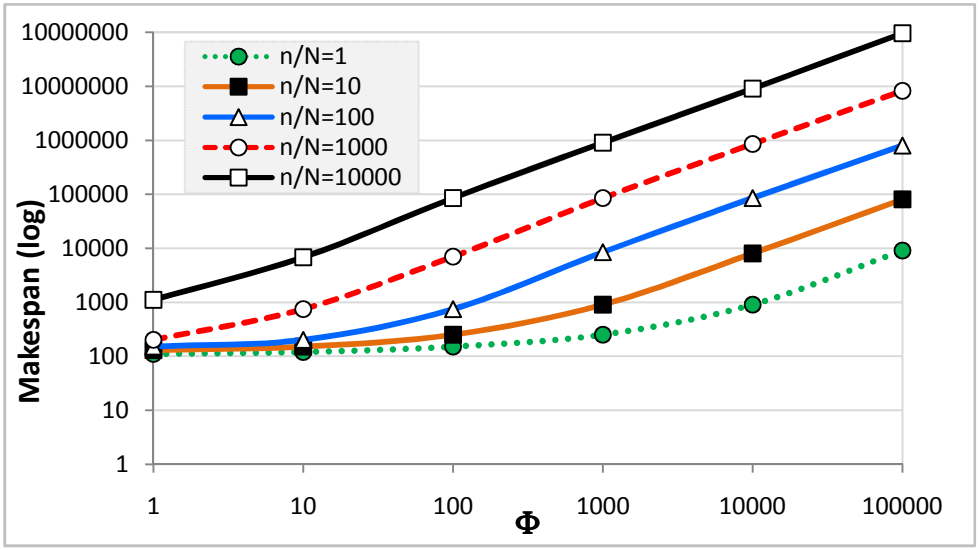


Lower is better

STB "in use" means "user watching TV" while task runs

- Experiment Setup
  - BLAST application running in a STB and compared with a reference PC desktop
  - STB with Brazilian middleware "Ginga"
  - Tests performed using the cheapest STB in the Brazilian market (~US$ 100)
- Remarks
  - Ref PC is ~31 times faster than STB "in use" mode
  - Ref PC is ~17 times faster than STB "standby" mode

Performance Assessment



- Simple analytical model was developed
- System parameters
  - Broadcast channel capacity =1Mbps
  - Return channel capacity = 150kbps
  - Image size = 10Mb
  - Application Input + output data size = 1kb
  - Average Processing time = from 53ms to 1.5hour

Research Roadmap

DONE

- Define an (ideally generic) architecture
- Preliminary analysis
  - STB basic performance assessment
- Proof of concept
  - Digital TV Network

NOW

- Complete analysis
  - Mathematical model, simulation
  - Case studies with different application profiles
- Security issues

FUTURE

- Optimization in specific components (e.g. controller)
- Business models
  - Voluntary computing model, reward model
  - Possibly with a real DTV broadcaster's partnership

Concluding Remarks

- ➔ OddCI: a novel approach to DCI
  - Efficient setup, on-demand instantiation
  - Great potential to enable DCI for Extremely High-Throughput Computing
- ➔ OddCI can be instantiated over a DTV system
  - Less processing power, but huge pool size
  - Brazilian DTV expects ~100 million receivers by 2016
  - European DVB: >500 million receivers deployed
  - Chinese DTMB: ~100 million receivers (estimated)
- ➔ Great research challenges to deal with

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