SASE

Schmidt Academy for Software Engineering

California Institute of Technology

Current Projects Completed Projects

Projects

The Quarter Century Sky: Data Reduction and Timescale Analysis On Transient Sky Surveys

A Photometry Pipeline and a User Interface for Automated Data Reduction, Long Timescale Analysis, and Data Visualization.

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The theoretical and practical schedule problem regarding methods to best sequence astrophysical observations for maximum scientific output is challenging. On a typical night or season, the potential number of observing sequences is combinatorically large and encounters further complications from observing conditions as Target of Opportunity (TOO) observations require facilities to adapt to transient phenomena. Further, the quality of potential observations may vary with time as observations may have sequential relationships that weather losses and other limitations can complicate. Thus, traditionally, sky survey data was collected through the manual involvement of human observers, but manual scheduling introduces significant drawbacks.

Several projects have implemented sophisticated schedulers to deliver semi-automated, global optimization solutions to reduce manual scheduling issues. Applying an integer linear programming algorithm for scheduling, the Zwicky Transient Facility (ZTF) has yielded an order of magnitude improvement in survey speed and adaptability compared to its predecessors. Reusing and improving the conceptual design of the Palomar 48-inch Samuel Oschin Schmidt Telescope, enables the identification of transients at high observing cadence within a significant fraction of the accessible night sky. ZTF's real-time alert system and analysis infrastructure enables large sequences of observations, essential for organizing and analyzing space-time patterns. As sizeable digital sky surveys such as ZTF start to represent a fundamental data basis for astronomy, it is increasingly clear that the design and implementation of a more efficient, consistent, and standardized archive architecture that can handle data from a wide variety of sky surveys are essential.

Through the Quarter Century Sky Project, ZTF researchers collaborate with the Schmidt Academy to extend the ZTF infrastructure by constructing an archive with a photometry data reduction pipeline, API, and a front-end UI to enable extended timescale analysis and data visualization of astronomical objects. The work standardizes and combines time series from prominent sky surveys, including the Catalina Real-Time Survey and the Palomar Transient Factory, to offer temporal baselines for observational astronomy from 4 to 25 years. The work opens up a deeper understanding of astronomical phenomena on decade timescales with systematic studies that are not currently possible. The cataloged data, including thumbnails of the discovery, reference, difference images, and a 30-day light curve history for an alert, are systematically archived based in a relational database management system. The system allows astronomers to pose complex analytical queries against organized, survey-wide catalogs. The study hopes to exponentially improve the efficiency of query operations that traditionally required astronomers to search through legacy archives that constitute more than 100 terabytes of data and will improve data management practices within time-domain astronomy as high-performance archives provide real-time distribution, characterization, and classification of alerts from these sky surveys.

ZTF will survey an order of magnitude faster than PTF.

	PTF	ZTF
Active Area	7.26 deg^2	47 deg^2
Overhead Time	46 sec	<15 sec
Optimal Exposure Time	60 sec	30 sec
Relative Areal Survey Rate	1x	**15.0x**
Relative Volumetric Survey Rate	1x	**12.3x**

3750 deg^2/hour

⇒ 3π survey in 8 hours

>250 observations/field/year

for uniform survey

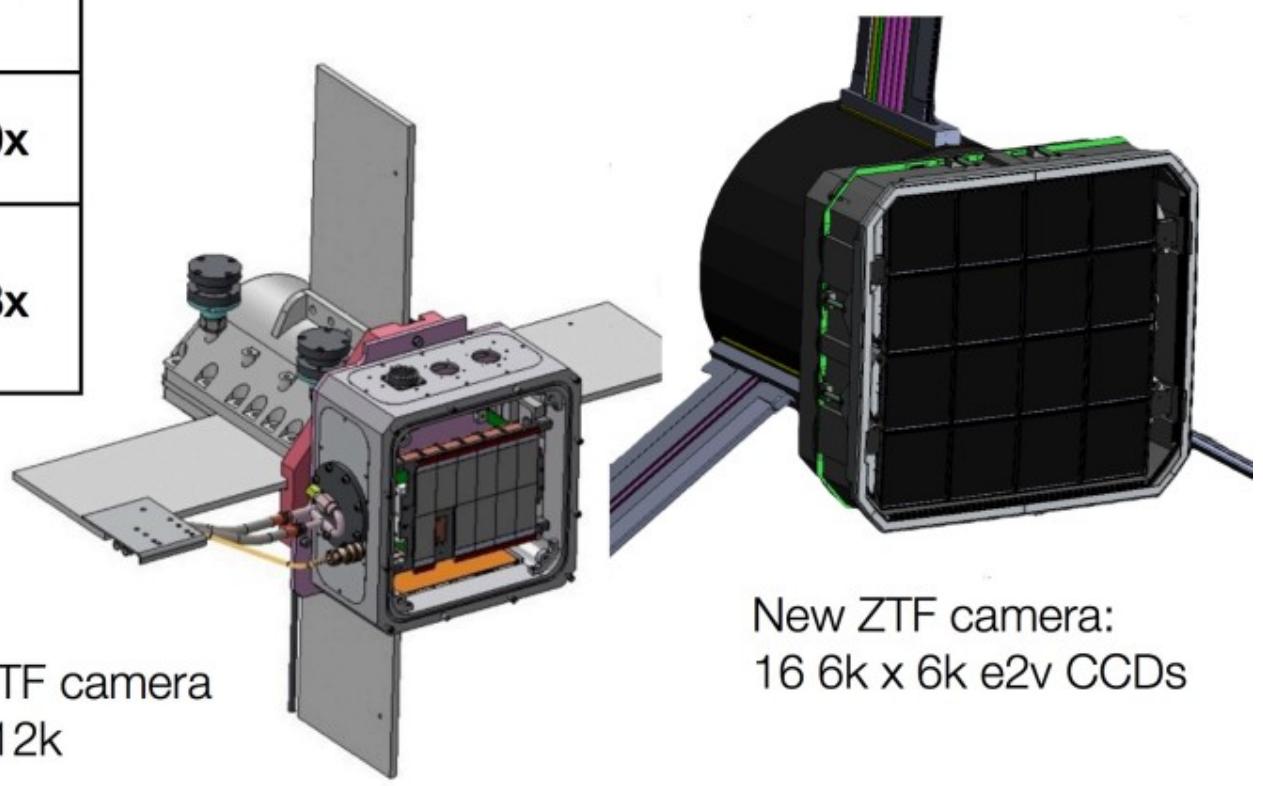

Figure 1: Table demonstrating ZTF's improved performance compared to its predecessor, the Palomar Transient Factory (PTF)

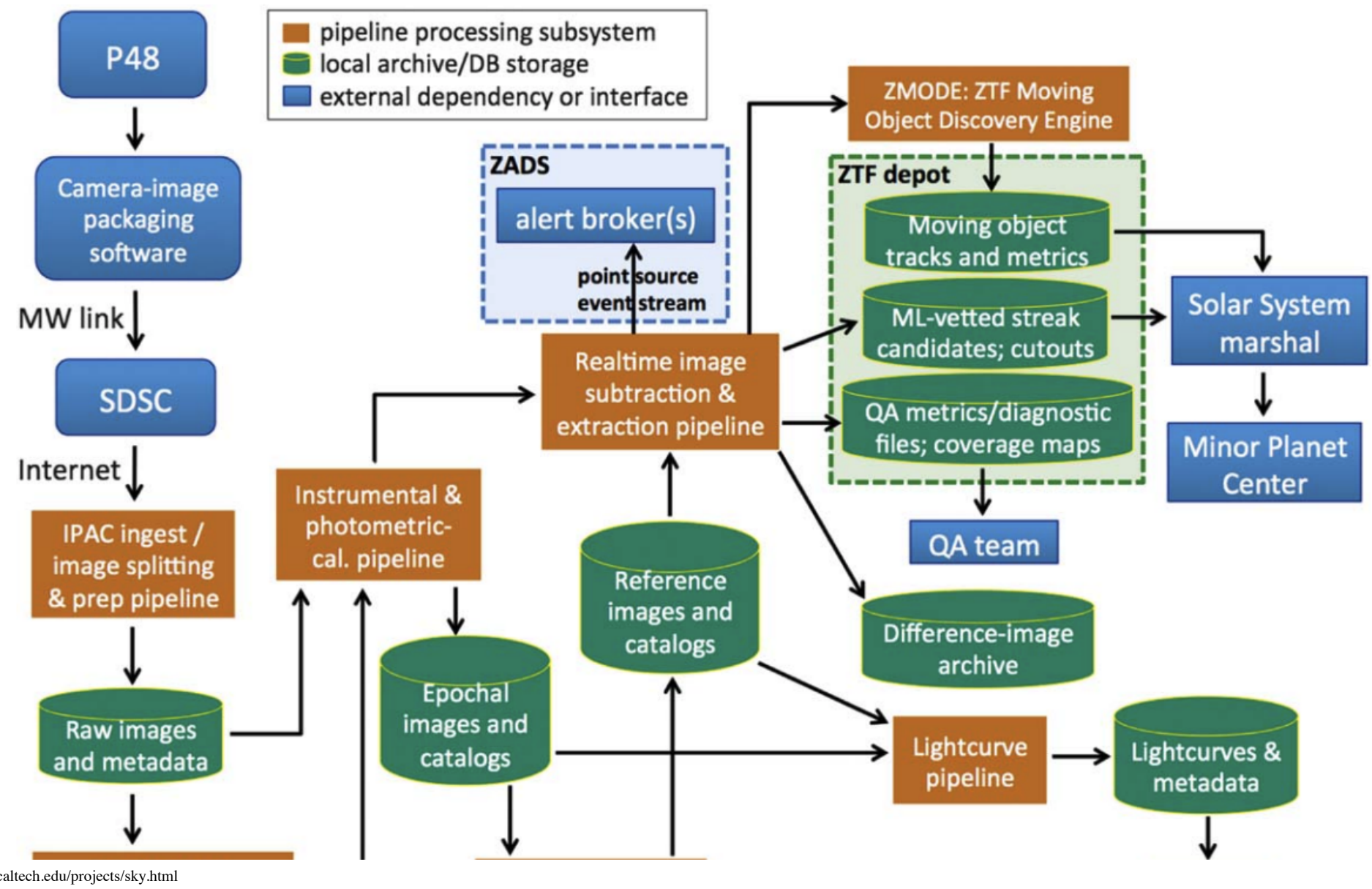

Figure 2: Overall data and processing flow in the ZSDS. Green components indicate storage in the form of an archive and/or database residing at IPAC to serve either the public or internal (private) collaboration. Vermillion (light brown) components represent the core pipelines. Blue components indicate external interfaces or dependencies.